THE PRACTICE OF HAND TURNING

8207

Prof Channing Whitaker

THE PRACTICE

OF

HAND-TURNING

IN

WOOD, IVORY, SHELL, ETC.

WITH INSTRUCTIONS FOR TURNING SUCH WORKS IN METAL AS MAY BE REQUIRED IN THE PRACTICE OF TURNING IN WOOD, IVORY, ETC.

ALSO,

AN APPENDIX ON ORNAMENTAL TURNING.

A BOOK FOR BEGINNERS

BY

FRANCIS CAMPIN.

SECOND EDITION.

LONDON:
E. & F. N. SPON, 48, CHARING CROSS.
MDCCCLXVIII.

PREFACE.

The object of the present Treatise is to lay before the uninitiated in mechanical manipulation a concise and practical account of those processes which are connected with the art of wood-turning.

In following out this object, we have continually endeavoured to select such examples of the art as might be sufficiently simple, yet capable of affording the student some experience in every manipulation which he may subsequently require.

Digitized by the Internet Archive
in 2018 with funding from
Getty Research Institute

https://archive.org/details/practiceofhandtu00camp

CONTENTS.

INTRODUCTION.

CHAPTER I.

ON LATHES.

CHAPTER II.

ON TURNING-TOOLS.

CHAPTER III.

ON TURNING WOOD, ETC.

CHAPTER IV.

ON DRILLING, ETC.

CHAPTER V.

ON SCREW-CUTTING.

CHAPTER VI.

MISCELLANEOUS APPARATUS AND PROCESSES.

CHAPTER VII.

TURNING PARTICULAR FORMS.

CHAPTER VIII.

ON STAINING, POLISHING, ETC.

CHAPTER IX.

ON SPINNING METAL.

CHAPTER X.

ON MATERIALS.

APPENDIX.

ON ORNAMENTAL TURNING.

THE

PRACTICE OF HAND-TURNING.

INTRODUCTION.

We have considered it desirable, before entering upon the description of the various manipulations with which the wood and general ornamental turner must be acquainted in order to become efficient in his art, to pass them somewhat rapidly in review, and to explain the general principles upon which they depend, whereby we hope to render the following chapters more interesting to the uninitiated reader, and also to prepare him for the processes contained in those chapters, Although at first sight the art of wood-turning appears sufficiently simple, on a closer inspection we shall find that many operations will require to be carried into execution of which the mere superficial observer has not the slightest idea.

Among these parasitic processes as we may call them, the following are those which appear most foreign

to our subject. Grinding and polishing, engraving, graduation; the use of these, however, we trust we shall hereinafter fully prove, but if we fail in this we doubt not that the amateur will in the course of his experience soon find means of employing them.

We may here give examples of some of the cases in which the above processes are required.

The amateur will doubtless frequently require to produce works in which various pieces of bright metal will be used, and of these some will have facets ground upon them. These facets cannot be properly wrought without having recourse to the grinding machinery hereinafter to be described for that purpose.

It will also frequently occur in the production of ornamental devices that tools or cutters with very accurately formed edges will be requisite, and these can scarcely be obtained without the use of a grinding lap. If a work in ivory or other similar material is required to be delicately engraved, the lines of the device being irregularly curved, some modification of the engraver's bench will be found almost indispensable to success.

Again, the processes of graduation and wheel cutting, the principle of which latter should be based upon the former if any accuracy at all is required, will not be without their uses to the wood-turner. Thus the preparation of click plates for eccentric and oval chucks, and also of rosettes for the rose-engine, or its substitute, is similar to that of toothed wheels, and

the click plates, when formed, are used in the same manner as small dividing plates.

Besides the occasions already mentioned upon which these processes are brought into operation, there will be numerous others, for although at the outset the amateur will most probably confine himself entirely to the production of such articles as may be formed in wood, he will by steps gradually advance to works in ivory, and from thence to such as are most conveniently constructed, either wholly, or in part, of brass or other metal of equal hardness; and to prevent the operator from meeting with any considerable obstacle to the execution of such, we extend our observations beyond the scope of wood-working into that of other materials, but at the same time we have not treated at all fully of metal-working, as that would require the expenditure of a much more considerable amount of space than we can spare in the present volume, and in fact we should far exceed the limits of our work if we directed our attention solely to the production of articles in metal. Instructions will also be given for the formation of the various tools, and we should advise the amateur to make his own tools whenever he can at all conveniently do so, as by taking this step he may assure himself of the quality, form, soundness and temper of his cutting instruments. It may be desirable to give the reader some information as regards the data by which he may conveniently judge of the

quality of his material. Pure iron, the nearest approach to which among the commercial irons is wrought or bar-iron, has, when drawn out under the hammer in all directions, a finely granular texture, but when it is rolled out into bars it consists of fine fibres running in the direction of its length. The fibres in a bar of wrought-iron may be made evident by fracturing a bar, or by acting upon it with dilute hydrochloric acid.

The strength and value of iron of this description depends upon the fineness and regularity of the fibre.

Wrought-iron does not, however, always retain the fibrous structure above referred to, but, on the contrary, it not unfrequently assumes a crystalline form, and this is especially the case when the article formed of this material is subject to vibration, alternate heating and cooling, or any action which tends to render it magnetic.

Certain kinds of iron are esteemed far more highly than the ordinary varieties, and by many this great superiority is attributed to the presence of titantic acid in the material, but it has also been found that other ingredients will improve the quality of the metal.

Cast-iron is not so pure as wrought, as it generally contains carbon, nickel, silicon, sulphur, and phosphorus, and sometimes other ingredients also.

Steel is formed from wrought-iron by heating it in contact with carbon, or from cast-iron by remov-

ing all impurities except carbon. In either case it appears most probable that the resulting steel is not a pure carburet of iron, but a cyanide of that metal, which is a compound containing nitrogen, carbon, and iron.

The following are the principal characteristics by which we may readily determine the comparative properties of cast-iron.

If the iron, when broken, exhibits a fine structure of a grey colour, it may be considered to possess the most desirable qualities for ordinary work, namely, it is tolerably tough, easily worked, and not very brittle.

If the metal exhibits a fine white crystalline fracture, its properties will be those of extreme hardness, not unaccompanied by a considerable liability to rupture if submitted suddenly to the action of transverse strain.

Specimens of metal which, when fractured, exhibit appearances varying from the fine grey to the white crystalline texture, have properties intermediate between those of the two foregoing descriptions, leaning towards one or the other in the same proportion as the fracture is more similar to one or the other.

Wrought-iron and steel may be judged according to the fineness and evenness of their structure.

In working with steel, the operator must bear in mind the fact that this compound is far more fusible than ordinary wrought-iron, wherefore it must not be subjected to so high a temperature. It may occa-

sionally be desired to form some apparatus in which necessity may occur for welding iron to steel; the execution of this will be attended with some difficulty, and, in fact, it will be found almost impossible, if not quite so, to weld cast-steel to iron. When, however, blister, or shear-steel, is to be welded to iron, the iron should be raised to a welding heat, and the steel to something short of the same temperature; the two are then shut together in the same manner as two pieces of iron.

If we attempt to weld to pieces of metal we shall find that the oxide which accumulates upon the surfaces of metal heated for this purpose will effectually prevent the cohesion of the two pieces; we must therefore adopt some means whereby the formation of this oxide may be prevented, or by which it may be removed at the instant of welding the metal. In order to effect this the iron is dipped occasionally, while undergoing the process of heating, into a mixture of white sand and common salt, which mixture fuses upon the surface of the iron, and dissolves the oxide, forming a silicate of iron, and the vitreous coating thus formed excludes the atmosphere, and prevents further oxidation of the material.

We have, however, dwelt almost too long upon this subject, which, although sufficiently important to warrant a more complete account thereof, will scarcely be of so great interest to that class of amateurs for whom this treatise is especially designed.

The various woods and other materials in which the operator will work, will be so fully discussed in a future chapter, devoted entirely to that subject, that any account of them in this place would be entirely superfluous.

We will now proceed to a review of those various processes with which the following pages are replete, and our attention will first be demanded by the explanation of our chief apparatus—the turning-lathe. Of this there is little or nothing to be said by way of introduction, as there is no principle involved in its construction which is not explained in the following pages. We may here, however, pause to consider the fundamental principle upon which the production of a surface is based.

A line may be said to be produced by the motion of a point, and also, from a similar course of reasoning, we may describe a symmetrical superficies as being formed by the motion of a line, and a solid by the motion of a superficies; thus, if we desire to produce a surface on any work, we may consider that portion of the substance which is cut away as being a solid, the form of which is regulated by the proportion of three lines, which correspondend to breadth, length, and thickness. A physical line is formed by the motion of the point of the cutting tool, and the surface is produced by placing a great number of these lines side by side, and very close together, and the necessary body of material removed by forming a number

of these surfaces successively, one below the other, and parallel to or concentric with the superposed surfaces, and the production of each of these surfaces is technically termed „taking a cut," the formation of the last surface being called the „finishing cut;" and in some cases it is important that this process should be conducted without any interruption to the work, an instance of which is found in boring a cylinder, for when the work has become expanded by the heat generated by the action of the cutting tool, if the operation of boring be for a time suspended, the periphery of the cylinder will again contract, and on this account the boring tool, if it be not readjusted, will, when the work is recommenced, take a somewhat deeper cut than that with which the proximate part of the surface was produced, thereby causing an irregularity in the contour of the cylinder.

From these remarks we immediately conclude that a plane surface, as obtained in the arts, consists of a number of minute grooves, instead of being a true plane, and also that a cylindrical surface, whether solid or hollow, is a fine spiral groove.

If the absolute accuracy of the work is not important, broad curved-edged tools are used, and the work smoothed with polishing powder, which will produce a figure more pleasing to the eye although less accurate than that obtained by the use of the point tool.

We may now turn our attention to the means of producing these surfaces—viz. cutting tools.

All cutting tools may be regarded as wedges, but scraping tools do not act solely as wedges, for they appear first to enter the work as wedges, but, to remove the material by a shearing action. The requisite form and hardness of the edge of any cutting tool is determined entirely by the strength and hardness of the material to be worked; and it may be accepted as a general rule that the harder materials require tools with more obtuse angled edges, and that no cutting tool will act upon a substance harder than itself. The reader will observe, that in our remarks upon hardening tools and pieces of work, we have directed them to be guided entirely by the tint which appears on the surface of the metal in judging of its temper; it may be desirable here to explain briefly the principles upon which the appearances mentioned depend. It is most generally believed that the sensation of light is produced by a series of rapid waves or vibrations, the colour of the light corresponding to the length of the waves. We can readily suppose that if two series of waves move in a parallel direction, and in such a manner that the crest, as we may term it, of one wave falls in the hollow of another, that these two series will neutralise each other. Hence, if a ray of ordinary light fall upon a transparent medium of such a nature that a portion of the light is immediately reflected from the surface of the medium, and another portion, passing through the medium, is reflected from the opposite surface, the two parallel

rays, or series of waves, may be so situated as to neutralise each other.

If all the colours composing the ray be not neutralised, the surface of the body will present various tints depending upon the colours which remain unaffected, and the thickness of the medium will determine the colour which shall be neutralised. This effect is called the interference of light, and we may readily conceive that it is to this property of luminous rays that the tints observed upon the metal are due, the thickness of the coat or film of oxide determining the colour; and as the thickness of this coat depends upon the temperature to which the work is exposed, we may safely accept the tint produced as a true indication of the extent to which the metal has been annealed, or tempered. The temperature which produces a dark blue tint will in the dark render the metal visible, the latter being at a low red heat. This temper is the lowest used when the material is required to be at all harder than in its natural state. Tools that are made of wrought-iron and case-hardened may have their cutting edges somewhat harder than those which are entirely steel, as the former being supported and rendered tough by the internal body of fibrous iron, are not so liable to fracture. Articles formed in cast-iron may be made extremely hard by being cast in moulds made of metal, or other equally good conductor of heat, and this property of cast-iron is occasionally inconvenient, as

the use of sand which has been wetted for the purposes of moulding—which wetting is resorted to when the sand is burnt or bad—gives rise to the formation of hard places in the casting which entirely resist the action of cutting tools.

In the chapter devoted to the construction and management of drills and drilling apparatus, we consider the most general forms under which these indispensable instruments appear, both for the execution of works in wood, and also for those in metal and hard materials; and while engaged in the examination of this branch of mechanical manipulation, the amateur will also find instructions for producing true cylindrical, conical, and other holes; all these processes we describe in detail, as being absolutely necessary. We also direct the attention of the student to the method of producing carved works, by the action of drills or rotatory cutters; but we have only touched slightly upon the construction and use of those tools which are designed solely for the execution of heavy work, which the amateur will not require.

Our observations upon drilling, boring, broaching, &c., being completed, we proceed to the scarcely less important subject of screw-cutting.

This subject is in reality far more comprehensive than it may at first sight appear, for it is not confined to the production of screws, but a great number of snails and other contrivances may be produced by applying the same principles slightly modified to suit

the special case with which we may have to deal. The amateur wood-turner may dispense entirely with the screw-cutting lathe, but on account of the interest of this process, and also because it has been frequently applied to the execution of curious designs, we considered that our treatise would not be complete if we omitted it.

If the workman is not possessed of the screw-cutting lathe, he must produce his screws and nuts by means of screw tools, taps, and dies. For the execution of such works full instructions will be found in the same chapter, and for small screws the screw tools will be found most expeditious and satisfactory.

Those parts of the present work above referred to are intended to instruct the beginner in the method of using each particular tool, and we should recommend him, while studying this portion of the art, to devote his attention to the form of those various instruments with which he works, and also to make himself thoroughly acquainted with the principles upon which the action of these tools depend, other wise he will experience some considerable difficulties in the execution of subsequent works, for if he does not fully comprehend the methods by which he puts his desires into execution, it can scarcely be expected that he will be able to adapt his tools to the work upon which he may be engaged.

Our attention is now called to the production of

various ordinary articles in soft wood, and, in treating this subject, we have endeavoured to lay before the student the details of the manipulations—connected with works of the most simple nature—whereby he may become duly exercised in the use of the commonest tools and materials; and we can assure him that, although the interest involved in the production of such works may not be sufficient to lead him to a repetition of these exercises, yet will he find that a careful observation of the various precautions necessary to be taken, in order to ensure a successful issue to his labours, will afford him such practical experience as cannot fail to be most useful in the execution of subsequent designs, and the time expended upon this elementary practice will also be fully repaid, as in its course the most convenient and rapid methods of manipulation will necessarily be discovered, whereby much thought may be saved in the execution of more complicated works.

When the amateur is initiated in the above subjects, he may proceed to the execution of works which require a far greater amount of skill, patience, and experience, such as those referred to in the chapter devoted to the consideration of the means to be adopted for the execution of turned works having special forms, the examples selected being such as we considered most fully answering to the requirements of the case—viz. that each form of which we treat should be a type of some series of forms.

In this section full instructions will be found for the execution of the celebrated Chinese balls, which are formed one within another, and the method here described is without doubt that originally employed. Perhaps the most delicate manipulation of which we treat in the whole course of the work, is that extremely elegant and ingenious method invented by Mr. Kittoe, for the production of covered vases from the egg shells of various birds, which method is so admirably adapted to the purpose for the execution of which it is designed, that by its means even the shells of sparrows' eggs may be safely operated upon.

We doubt not that the most interesting chapter in the present work, though it is perhaps of the least practical importance; will be that in which the execution of varied and curious designs by the use of the eccentric, elliptic, and rose-engine chucks is detailed; we say that this is the least important, as the manipulations therein described tend to the production of ornamental rather than useful works; but we do not mean by this to depreciate the elegant productions of these ingenious devices, and it is a matter of regret that we have not been able to introduce a description of a certain apparatus termed a geometric chuck, which instrument is so contrived that by its means an almost endless variety of designs may be executed; but the scope of this subject is such as to preclude any account of it in a work not devoted entirely to that purpose.

Of the recipes for various stains, varnishes, &c., we have no remark to make in this place, beyond that they are all carefully selected.

We have deemed it desirable also to describe a process employed for the production of raised works in metal, confining our remarks, however, to such works as the amateur may conveniently execute; and while treating of the raising of such works in the lathe, a process termed spinning, it has been found undesirable to take leave of the subject without instructing the student in the manner of producing fluted or other raised surfaces which cannot be manipulated in the lathe; the process by which this is effected is technically termed snarling up.

The last chapter, that on miscellaneous processes and apparatus, contains accounts of such supplementary manipulations as may be found either convenient or requisite, but which could not be introduced into any other part of the work consistently.

CHAPTER I.

ON LATHES.

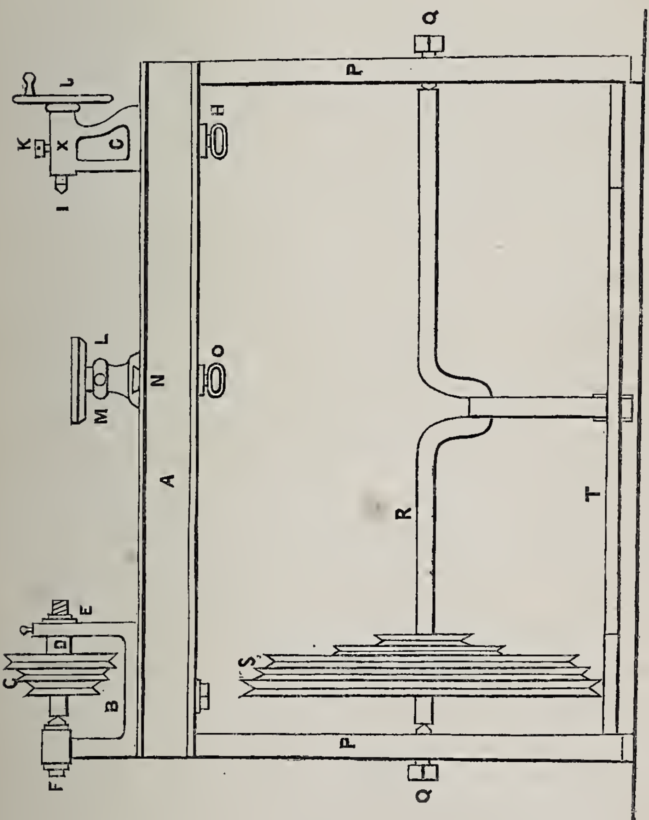
In the present chapter we purpose describing such lathes as are adapted to the requirements of the amateur.

The ordinary lathe is a machine in which rough materials may be brought accurately to any form whose section at right angles to its axis is a circle. The principle of its construction is that of a cylinder revolving (in suitable bearings) on a fixed axis, and to the extremity of this cylinder are attached various contrivances called chucks, for holding the material whilst it is being operated upon. The same principle is exhibited in various forms, as the potter's wheel, the watchmaker's tool, and the ponderous and complicated machine of the engineer.

The apparatus generally employed by wood and ivory-turners is termed a foot-lathe, on account of its being driven by the foot in the same manner as the common grinder's wheel; some are constructed partly

in metal and partly in wood, but those made entirely of metal are far superior to these, and are of the following construction.

Fig. 1.



A, fig. 1, is the bed of the lathe, upon which two supports, called poppet-heads, rest; the surfaces of contact vary in form, in some beds both are flat, in others both angular, and in others one angular and the other flat.

By many the angular, or V beds, are preferred, from the idea that the heads are more likely to retain their proper position than when resting on plane surfaces; but the latter, when accurately planed and fitted, are quite as worthy of reliance, and far more convenient than the angular bedded lathes.

B represents the head to which the chucks are attached, and by means of which the power requisite for rotating the work is applied. This poppet-head consists of a strong frame of cast-iron, F B E; in the standard, E, is fixed a hard conical bearing, in which one end of the mandril, D, revolves, and by which it is supported, the other end resting against the hard conical point of a screw placed in a nut, at F; by means of this screw the mandril is kept tight up to its bearings, any tendency of the screw to shift being prevented by one or two nuts upon it, which are screwed up tight against the standard, F.

At the bottom of the head is a solid projection, which is made to fit the opening between the sides of the lathe-bed, and by which the parallelism of the lathe-bed and mandril is maintained. The head is firmly fixed in its position by a bolt, which draws a strip of metal up tight against the bottom of the lathe-

bed. A number of groove-pulleys, G, are attached to the mandril, one of which is connected with the pulleys, S, on the driving-shaft, R, by means of a cord of catgut, or gutta percha, although in a case of necessity a sash-line may be made to answer the purpose. The cat gut is, however, the most satisfactory on account of its great durability. The plan usually adopted for joining the ends is to screw on hooks and eyes, the end of the gut is slightly tapered and damped, so that the hooks and eyes may squeeze the gut into a screw rather than cutting it, by which latter the band would be much weakened.

It must not be used until the gut is dry and hard. Gutta percha bands are united by heat, the ends being cut off obliquely thus , and gently heated by means of a hot piece of smooth clean iron, until soft, when they are firmly pressed together, and kept in that position until cold. This, of course, necessitates the stoppage of the lathe for some time, besides shortening the band every time it is united.

When the work is too long to be supported entirely by one end, a second poppet-head is required, which is of the form shown at C; this head is accurately fitted to the lathe-bed, and can slide upon it to allow of adjustment to the length of the work; it is fitted with a clamping-screw, H, to fix it when in position, also a conical point, I, called a centre, which is movable through a small space by the handle, J, to allow the removal of the work from the lathe with-

out shifting the poppet-head. The mandril carrying the centre is fixed after adjustment by the capstan-headed screw, K.

The next part of the apparatus to which our attention is called is the rest upon which the operator supports the turning tool. There are two kinds, the common rest and the slide rest; the former is that represented in our figure. M L is a short hollow column, provided with a foot sufficiently long to reach across the lathe-bed; in the bottom of the foot is planed a dove-tailed groove, N, which retains the head of a clamping-screw, O, but at the same time allows of a sliding motion when not clamped. From this it is evident that the rest can be placed and fixed in any position.

Within the hollow column is a cylindrical rod, which carries a straight strip of metal, the whole being raised or lowered by sliding the rod vertically in the column; when the proper elevation has been attained, the rest is fixed by a screw working in a thread cut in the thickness of the column.

The lathe-bed is supported on standards or frames, P P, which also serve to carry the crank-shaft, R, by means of two conical pointed screws, Q Q, which enter countersunk recesses in the ends of the shaft. The shaft is made with one or two cranks, or throws, according to its length. This shaft is also fitted with grooved driving pulleys, S, made of various diameters in order to obtain any speed which may be required.

The pressure imparted to the treddle, T, is communicated to the crank by a link with a hook at each end, or by a chain; some turners preferring the former, and others the latter.

We now proceed to consider the means by which the work is held in the lathe and caused to rotate with the mandril.

FIG. 2.

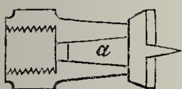


Fig. 2 represents the fork, prong, or strut-chuck, so called from the steel fork or prong, *a*, which is fitted into the square socket of the chuck; this chuck is used for long pieces, the point supporting one end of the work, the other being supported by the back centre. The chisel edges on each side of the point take hold of the work and ensure its rotation. The fork being fitted into a square recess in the chuck may be replaced by drills, &c., or small pieces of wood or ivory to be turned. It is usually made of metal, and attached to the mandril by an internal screw corresponding to that on the nose of the mandril.

FIG. 3.

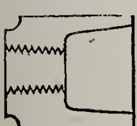


Fig. 3 represents the hollow or cup-chuck; it is used for holding short pieces, or pieces that are to by turned out hollow. Its inside is turned slightly conical, so that the work may be driven tightly into it.

This chuck is usually made of boxwood, sometimes strengthened by a metal ring round the mouth

of it; but this is scarcely necessary, as a very slight blow is sufficient to fix the work if it has previously been reduced to a form nearly approaching the circular, by the chisel, paring-knife, or other tool.

FIG. 4.

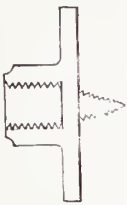


Fig. 4 represents the face-plate, or facing chuck; it may be made of iron or other suitable material.

This chuck is turned flat and perfectly true, and is fitted at its centre with a conical screw to hold objects to be turned on the face. This chuck can only be used when the hole made in the work is not objectionable, or can be plugged up. The screw should only be very slightly taper, otherwise the work will not hold when reversed.

FIG. 5.

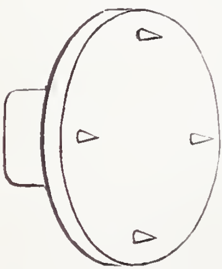


Fig. 5 a chuck for flat work, where a hole in the centre would be detrimental. It is a face-plate with three or more small spikes projecting from its surface to penetrate the material to be wrought, which is held against it by the back centre.

A plane face-plate is used where the work cannot be conveniently fixed to either of the two foregoing, as in the case of thin pieces of horn, tortoiseshell, &c. The work is attached by means of glue or turners' cement.

FIG. 6.

Fig. 6 represents the arbor-chuck, usually made of brass. It is used for holding small hollow works, or rings.

For very small work, fig. 2 is useful for holding the arbors in place of the strut *a*.

FI. 7.

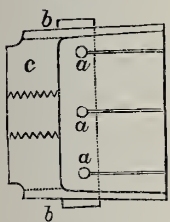


Fig. 7 represents a spring-chuck which is used for holding very slight work, that requires to be hollowed out.

It is turned conical externally, the apex of the cone being to the left. A few holes, *a a*, are drilled through the chuck near its base, and at equal distances from each other. From these holes saw kerfs, or slits, are cut longitudinally to the front of the chuck, which allow the chuck to expand slightly to take a firm hold of the work, and when the work has been forced into the chuck, the grip is rendered still more firm by draving a strong ring towards the front of the chuck.

These chucks are sometimes made of wood, but those of metal are much neater and more convenient; they may be made of a piece of brass tube firmly driven on a wooden block.

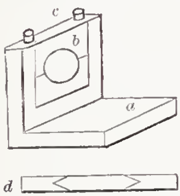
A similar chuck is used for holding hollow work, but instead of being provided with an external ring it is fitted with a short solid plug, which is forced

forwards after the chuck has been inserted into the work. When long and slender pieces have to be turned, an extra poppet, or a support, is required, to keep the work from shaking, or chattering, as it is termed.

Fig. 8.

It is generally made of wood, and is formed similar to fig. 8. It consists of a head, in which is bored a hole, *c*, of the proper diameter, and a tail-piece fitted to the lathe-bed and sufficiently long to receive an apperture, *b*, through which a wedge may be passed, to hold it down firmly upon the lathe-bed.

Fig. 9.



Another and more convenient form of support is shown at fig. 9: *a* is a cast-iron frame, having a foot fitted to the lathe-bed, and furnished with a bolt and nut, by which it is firmly bolted down to the lathe-bed; *b* is a block of wood fitted into the frame, where it is secured by the cross-bar, *c*. An aperture of the required diameter is now bored in the block; it is then taken out of the frame and sawed in half, so as to form a top and bottom bearing; *d* shows a section of the frame; any other form of groove may be used, but we have selected the v on account of the ease with which the blocks may be fitted to them. One great advantage of the latter apparatus is, that the two bearings may be brought together when the hole is worn. When a slide-rest is used, this additional support should be attached

to it; it will then keep close to that part of the work on which the tool is acting, by which a more satisfactory piece of work is turned out, and the trouble of shifting the poppet avoided. The application of a little grease to these bearings will sometimes be found beneficial.

An apparatus called a boring collar, somewhat similar to that just described, is used for supporting the ends of pieces of which the ends are to be bored, and which are too long to be held by the cup-chuck alone. It consists of a plate similar to a face-chuck,

Fig. 10.

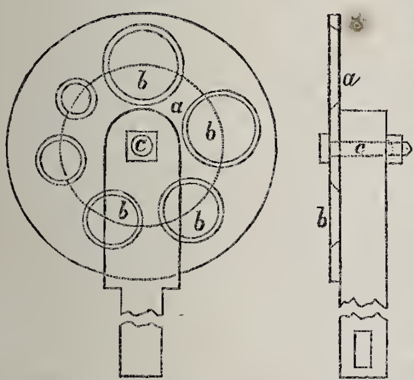


fig. 10, through which a number of conical holes are bored, whose centres are equidistant from the centre of the plate, so that when the latter is turned on its axis any hole can be brought exactly in a line with the two centres. The plate may be attached to a standard similar to either of the foregoing.

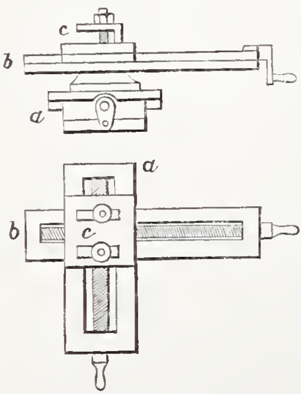
It may sometimes occur that the work to be turned, as a wheel, the foot of a stand, &c., may be rather too large for the lathe; in this case it will be required to raise the poppet-heads. This may be done by pieces

of wood, but it is far more convenient to have frames truly planed and fitted. Such a frame is shown at fig. 11. It is made of cast-iron, the top being fitted to the bottom of the poppet, and the bottom being fitted to the lathe-bed, care being taken that the mandril is retained parallel to the lathe-bed. The rest may be blocked up in a similar manner, or a temporary rest may be made of a piece of bar-iron bent to a suitable form.

Fig. 11.

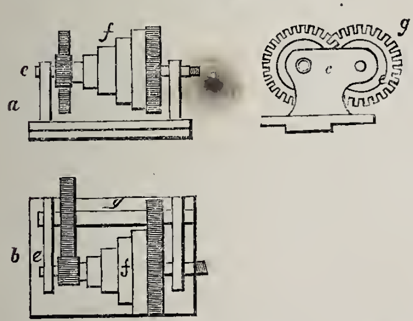
In some cases it will be very convenient to have a self-acting slide-rest, as for turning large screws, spirals, &c. The slide-rest is shown in fig. 12. In the accompanying figure the upper sketch is an elevation, and the lower a plan. *a* is a slide which fits the lathe-bed very accurately, but will yet slide freely upon it, and in a direction exactly parallel to the axis of the object to be turned. *b* is another slide fitted to the lower one, and sliding upon it in a direction at right angles to the lathe-bed. It is worked by a screw attached to the lower slide, which gears into a nut fixed to the bottom of the

Fig. 12.



slide *b*. Upon the slide *b* is fitted a small slide *c*, upon which the turning tool is fixed by means of a clamp. This slide is moved in a direction parallel to the lathe-bed, by means of a screw attached to the slide *b*, gearing in a similar manner to that in the slide *a*. The whole slide may be moved along the bed either by hand or by means of a screw running along the side of the bed, and gearing into a nut made in two halves, so that it may be thrown into or out of gear by closing or opening the nut. The use of this screw, which is called the leading screw, requires a different form of fixed poppet-head, and constitutes what is called a screw-cutting lathe, on account of its suitability to that process.

Fig. 13.



The poppet-head generally fitted to self-acting lathes is represented in fig. 13. *a* is a side elevation, *b* a plan, and *c* a front elevation. This head is fitted with speed pulleys, *f*, which may be made fast to the mandril, so as to drive it direct or loosened, and geared by a tooth-wheel, with the shaft *g*, which again gears into the mandril, which is supported in bearings at each end. The wheels on the shaft *g* are thrown out of gear with those on the man-

dril by sliding the shaft endwise in its bearings. It is retained in or out of gear by a pin passing into the bearing, which rests against a groove turned on the shaft *g*. On the end, *e*, of the mandril a toothed wheel is slid and retained there by a nut. This wheel may act directly upon another placed on the end of the leading screw, or may be connected with it by means of one or two intermediate wheels, according to the speed required, and the direction of the intended screw.

It is evident from this arrangement that any ratio between the speeds of the mandril and leading screw may be obtained, either for cylindrical turning or screw-cutting. Some lathes are also furnished with gearing for self-acting the second slide; one has been patented, in which the top slide is self-acting at any angle, and by the combination of these motions various forms may be obtained without any trouble on the part of the operator beyond adjusting the lathe before starting it. This last lathe is very suitable to the requirements of the amateur, and is applicable to every kind of small turning, but they are somewhat complicated, and therefore costly, and from their not being sufficiently strong for the purposes of the engineer, they have not come into general use. In this lathe the bed is made solid at top, and the leading screw placed within it, by which arrangement it is protected from chips, &c.

We now proceed to consider the various tools and other preparations required in the processes of turning.

CHAPTER II.

ON TURNING-TOOLS.

In the present chapter we shall not confine ourselves to such tools as are used only with the lathe, but will also describe such as are required for the preparation of the material to render it fit for the lathe.

Fig. 14.

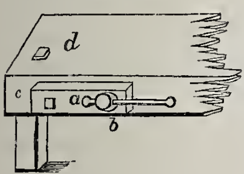
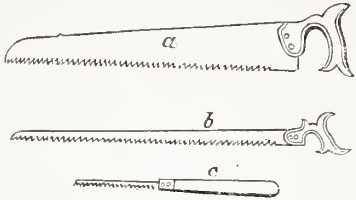


Fig. 14 represents acommon bench-vice it consists of a strong piece of wood, *a*, which may be drawn tightly up to the side of the bench by means of a screw, *b*, which works in a nut attached to the bench; it is also provided with a wooden guide, the end of which appears at *c*. This vice is used to hold pieces of wood during the operations of sawing, planing, &c. There is also a stop, *d*, fitted to the bench, against which larger pieces of wood which are to be planed may conveniently be rested. Both hand and tenon saws will be required; of the former there are several forms, a few of which are shown in the accompanying sketch.

Fig. 15.



a, fig. 15, represents the most ordinary description of hand-saw; the teeth should be slightly turned aside, the alternate teeth inclining in the same direction, whereby a cut somewhat wider than the thickness of the saw is made.

b represents a circle-saw, similar to the former in everything except depth; this saw being very narrow, in order to allow of its passing round circles or curves.

c is a keyhole-saw, much narrower and thinner than the foregoing; the handle is made hollow, and the blade may be slid more or less within the handle, being fixed by set screws in any required position. We think it desirable to take this opportunity of describing a few of the processes connected with the manufacture of saw-blades.

The saw-blades are cut out from sheets of steel, and the teeth punched out in a fly-press; the wire edges left on the teeth by this process are afterwards removed by filing.

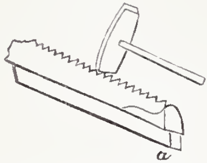
For very fine saws, the teeth may be cut by a chisel, the edge of which is inserted each time at the side of the notch previously made, and the chine makes the following indentation: the intervals being thus made truly equidistant, the teeth are completed with a file. The next process is hardening. The saws

are heated in a long furnace, and then immersed horizontally and edgeways into a trough containing oil, in which such ingredients as tallow, suet, bees-wax, &c., have been dissolved. When the saws are removed from the trough they are hard and brittle, and require tempering; this is done by wiping a part of the grease off and setting fire to the re-remainder; the softer the saw is intended to be, the more grease should be burnt off. Back-saws are those which are furnished with stout brass or iron backs, which serve to keep them straight. They are made in lengths of several feet, and afterwards cut up into three or four saws. These saws are used chiefly for very accurate work, such as tenons and dove-tails, whence they are called tenon, or dove-tail saws.

The saw-blades, after being tempered, are rendered more hard and uniformly elastic by being hammered on every part of their surfaces. This operation, which is called planishing, being finished, the blades are ground at the wheel or grindstone. The flatness and elasticity of the saws are impaired by grinding; they are therefore again planished, and the saws heated until a faint straw-colour appears on their surfaces, when the final polishing and cleaning is proceeded with.

The last process in the manufacture of saws, and one which will sometimes have to be repeated after they have been in use some time, is the setting of the teeth, which is performed as follows:

FIG. 16.



A small anvil or stake is fixed in the vice, and upon this the saw is laid, as shown in fig. 16. Every alternate tooth is now struck with a small hammer, so as to bend it round the curved surface of the stake; the saw is then reversed, and the remaining teeth bent in the opposite direction.

Besides a few saws, the turner will require a small axe for removing the edges of the rough material; a draw or paring knife for bringing the material to a rough circular form; a jack-plane and smoothing-plane for preparing flat surfaces; one or two chisels and gouges; a few brad-awls and gimlets of various sizes; a hammer and mallet; an oil-stone and slip; a glue-pot and brush.

With regard to the chisels, &c., we may observe that these, in common with other edge-tools for cutting wood, are hardened by plunging into cold water when red-hot, and tempered by being reheated until a dark straw-yellow or purple colour appears upon the surface of the metal.

For operating on work in the lathe, the only cutting tools that will be required at first are a few gouges for taking off the rough edges and working out the curved lines; some chisels for straight work; side-tools for side and hollow work; a hook-tool for hollow work; a point-tool for hard material, and a parting-tool for cutting through work. For measuring

Fig. 17.

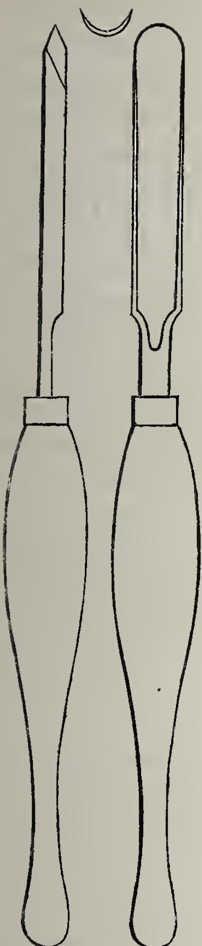
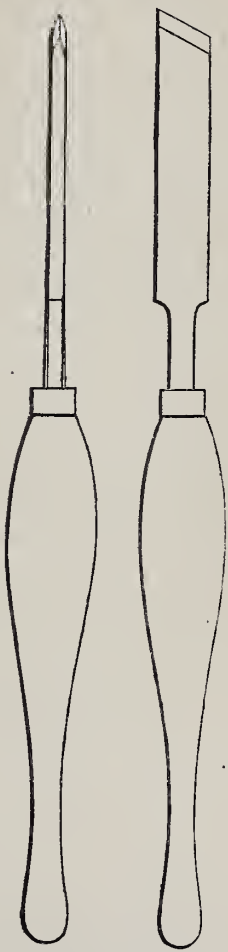


Fig. 18.



and setting out the work there will be required a

rule; a pair of compasses, or dividers, for laying off distances; a pair of callipers for taking diameters and thicknesses; a square and a straight-edge for ascertaining the rectangularity of work, and the straightness of cylinders and flatness of surfaces.

Fig. 17 represents a gouge which varies in breadth from a quarter of an inch to one inch and upwards. The larger sizes are used for roughing out the work; they are fixed in long handles so that they may be held under the arm to insure greater steadiness; it is ground from the outside, and presents an elliptical cutting edge.

Fig. 18 represents a top and side view of a turning-chisel. It consists of a taper piece of flat steel of any required width. Its cutting edge is not ground square to its length, but at an angle, as shown. The edge is ground with a double bevil, or from both sides. These chisels, like the gouges, are fitted into long handles, and for the same reason.

Fig. 19.

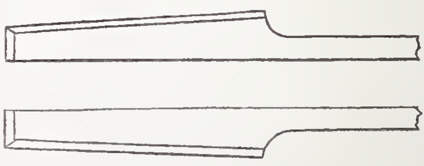


Fig. 19 represents a right and a left-hand side tool. They are each furnished with two cutting edges, one at the end and the other on the side. These

tools are used chiefly for facing the ends of cylinders, and for turning out hollow work.

Fig. 20.

Fig. 20 shows the form of the point tool. This tool is used as a right and left side tool, and also as a point tool for reducing hard material. The surface produced by this tool is in fact an extremely fine thread, like a screw.

Fig. 21.

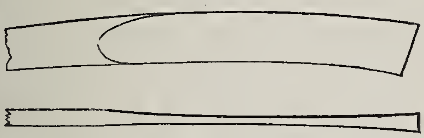


Fig. 21 shows a side elevation, and a plan of the parting tool. It is made of a piece of flat steel, and ground hollow on the sides that it may clear the work while passing through. This tool may also be used for cutting grooves round a cylindrical piece of work. When the parting tool is intended for such work as cutting through the face of a plate to reduce its diameter, it should be made narrow, and ground thinner at the bottom than at the top. This tool is sharpened by grinding the top surface.

FIG. 22.

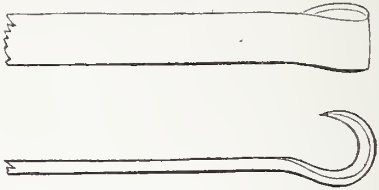
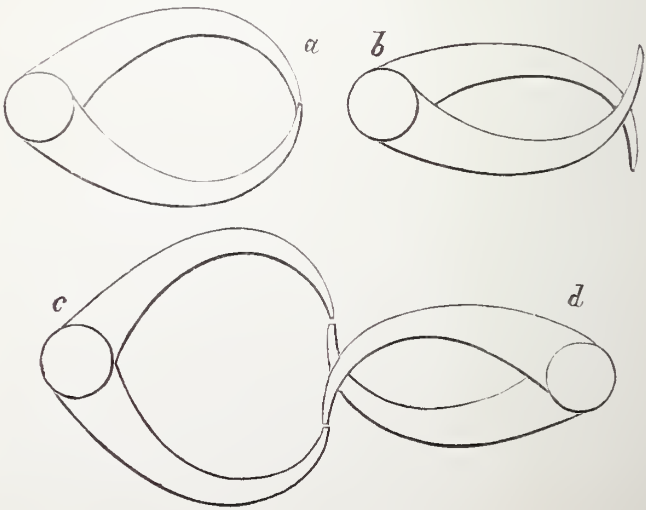


Fig. 22 represents the hook tool, the upper sketch being a side view, and the lower a top view. The edge is ground with the bevil or chamfer inside. This tool will be found very convenient for turning leather, and may sometimes be useful for hollow work. The rule, compasses, square and straight edge, aro too well known to require any description. The callipers being seldom used for other than cylindrical and hollow works, require a description.

FIG. 23.



The callipers are formed of two curved blades or legs, as shown in fig. 23, and are so constructed that although the points meet fairly together, the legs by a slight side pressure can be moved over each other as shown at *b*, in which position internal diameters may be taken. The ends should not be too broad, or they will, when used to take internal dimensions, give a result less than the actual size. It is usual, when it is required to measure a hole with great accuracy, to use a pair of callipers, *d*, having very fine points, and from the dimensions obtained by these, the size of the corresponding solid cylinder may be obtained with another pair of callipers, *c*, as shown.

The necessary accuracy of adjustment can hardly be attained by the pressure of the hand. It is therefore usual to gently tap the blade of the instrument upon the lathe-bed, or other hard substance, by which means very accurate dimensions of any object may be obtained.

It is evident that the callipers just described are inapplicable to taking the thickness of any undercut or recessed part, and the following form is therefore resorted to.

Fig. 24.

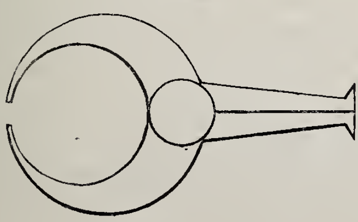


Fig. 24 represents a pair of inside and outside callipers, which show at once the two measurements; or if the curved blades are applied to the thickness of a recess, this thickness may be taken from the other end of the callipers, previous to removing them. These callipers are not in such general use as the foregoing, on account of their accuracy becoming impaired by the wear of the points.

Some callipers are made with a segmental scale of inches attached to the joint, and these may be used for measuring undercuts, &c.; but they are liable to the same inaccuracy as the foregoing.

Both dividers and callipers are sometimes made with a spring instead of a joint, the instrument being closed by a wing-nut working on a fine screw; the dividers so made are convenient when they are required to retain any measurement for a length of time, but the callipers have the disadvantage of being applicable to only one kind of measurement, external or internal.

Before closing the present chapter, it appears desirable to give some instructions with regard to the formation of the edges of cutting tools.

The first point to be considered is the angle at which the planes forming the edge should meet, and finally the means by which these planes are to be obtained.

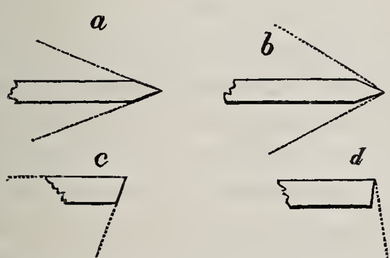
The nature of the material to be operated upon most materially affects the cutting angle of the tool,

the angle of application, and also the speed at which it is to be wrought.

As a general rule, the softer the material the more acute may the angle of the cutting edge be, the greater the speed of the lathe, and the nearer the approach of the axis of the tool in application to a tangent to the work. For very hard woods, ivory, shell, &c., a very obtuse edge is required, and the direction of the axis of the tool should make an angle of about 85 deg. with the tangent to the work. All hard materials should first be reduced to the circular form by means of the point tool.

The angles of cutting tools, intended for turning the soft woods, should range between 20 deg. and 30 deg.; for hard wood and ivory, from 40 deg. to 80 deg.; and for brass, copper, iron, and steel, from 70 deg. to 90 deg.

Fig. 25.



It is almost impossible to give too much care to the grinding of cutting edges, as upon the accuracy of the tool the neatness of the whole work depends.

a, fig. 25, represents a well ground edge of a double bevilled chisel for soft wood. *b* shows the same chisel, with the edge ground round, whereby the angle is very considerably vitiated, as shown by the dotted tangents, whereby the material will not be cleanly cut.

c represents the cutting edge of a tool for iron, having an angle of about 85 deg. or 90 deg. *d* represents the same edge, badly ground, and in this case the result is even worse than in the former, as the roundness of the front plane will entirely prevent the edge from cutting, and it can only be brought into action by placing the edge of the tool below the axis of the object to be turned, and in position it can only scrape, which action is accompanied by a continuous chattering of the tool, producing rough and unsightly work.

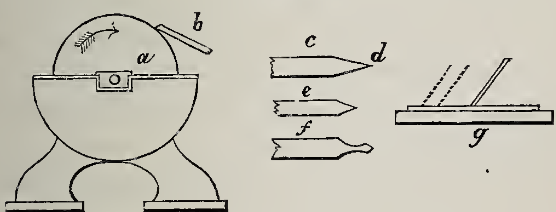
We will now detail the means by which good cutting edges may be ensured.

The tool is brought to a bright surface of the required form by forging and filing; it is then properly hardened and tempered. The various sides are then polished on the grindstone. For the final grinding a stone of small diameter should be used; it may be worked either by foot direct, or by being so constructed as to fit the lathe centres; and in either case it must be kept well supplied with water, in order to prevent the tool from becoming heated,

wherby the temper would be reduced. This may be most conveniently accomplished by having sufficient water in the grindstone trough to reach the bottom of the stone, but care should be taken to remove the water before setting the stone aside, otherwise the lower part o fit may become softened.

We will select, as an example, the grinding of a chisel as shown at *a*, fig. 25.

Fig. 26.

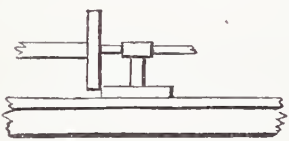


a, fig. 26, represents a grindstone, the direction of its revolution being indicated by the arrow; *b* is the tool to be ground, which should always be so held that the grindstone is driven from the edge towards the handle, as shown, otherwise it will discover a great liability to become wire-edged, as shown at *c*, *d* being the wire-edge, which will bend backward and forward and cause loss of time and trouble, as it will have to be ground off, and the tool must be re-formed. The use of a small grindstone causes those surfaces of the tool which are ground to become slightly hollow, as

shown in the annexed sketch, *c*; this causes the angles to be rather more acute than they were intended to be, but this is no disadvantage. When the tool has been brought to as accurate a point as may be by the grindstone, it is finished off upon a slip of oilstone, *g*, whereby the cutting edge is reduced to the proper angle, and the surfaces bounding it are finely polished. Great care must be taken in moving the tool along the oilstone to keep it always parallel to its first position, otherwise the edge may be rounded in this operation. The ultimate form of the cutting edge is shown with an exaggerated contour at *f*.

For grinding small tools, which require to be very accurate, more reliable machinery must be had recourse to.

Fig. 27.



For finishing off small tools and such as require great accuracy, the apparatus shown in fig. 27 will be found convenient. It consists of a disc made of an alloy of 9½ parts of lead to 1 part of antimony; it may be made to fit the nose of the lathe mandril, and when screwed tight on to the mandril it should be faced perfectly true. Some very fine emery or crocus is rubbed on this disc, in which it becomes imbedded, the whole forming a very delicate grinding apparatus. The

crocus should be very carefully prepared according to the recipe given in the fourth chapter of this work. To the lathe-bed is attached a frame, which is furnished with a socket, in which the tool to be ground may be firmly fixed by set screws, which socket moves upon a hinge connected with a graduated arc, by which to determine the angle.

CHAPTER III.

TURNING IN WOOD, IVORY, ETC.

WE shall commence the present chapter with instructions for turning the simplest forms, from whence we shall lead the beginner, by degrees, to such of the more complicated specimens as are producible by means of the common lathe.

The lathe having been properly oiled and otherwise attended to, and a piece of wood selected, the next step will be to reduce the material to a fit condition for turning. If the stuff is very much larger than the intended article, a piece of a convenient size should be sawn off; this being done, the rough edges may be removed with an axe, and the material then further reduced by means of a carpenter's chisel.

Let us suppose that a cylinder is required, and that it is too long to be held in a cup-chuck without some other support.

Make, with a gimlet, a small hole in the centre of each end, then place one end against the projec-

tion or spike of the fork, or strut-chuck; then strike the other end cautiously with the mallet until the knife-edges of the chuck are firmly embedded in the material. The back poppet-head must now be brought up to the work and firmly fixed by means of the clamping-screw attached to the bottom of the head, and this being done the steel centre of the back head is worked forward by the screw within the mandril, which carries it into the hole prepared for it with sufficient force to prevent the work from having an end-long motion, but yet allowing it to revolve freely. The gouge is now applied tangentially to the work at right angles to its axis, as shown in fig. 28, to remove the angular edges left by the chisel or draw-knife.

This action will produce a series of parallel rings or grooves round the cylinder, which are subsequently removed, partially by the end-long movement imparted to the gouge, and finally reduced by the chisel to a true surface.

Fig. 28.

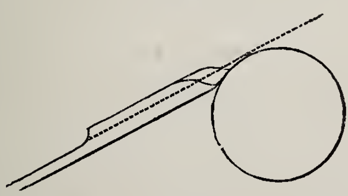
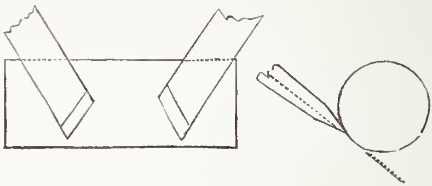


FIG. 29.



The chisel should be held tangentially to the work, as shown in fig. 29, but not at right angles to its axis; it should also be continually traversed along the work.

By traversing the chisel thus obliquely along the work, its cutting action is rendered very smooth, and all risk of the corner of the tool cutting into the work is avoided.

Narrow tools should always be employed in roughing out the work, and if it is at all hard the point tool will be found most convenient. If a broad tool is used it will be found that its continual concussion against the various projections and irregularities will produce a tremor or chattering action, which will entirely destroy the accuracy of the work.

Some turners consider the rounding down of the material previous to turning it as unnecessary, but it will be generally found that it saves time, especially to the beginner, who is very liable to a multiplicity of inconveniences and accidents if he uses his material in a very rough state. The most important

of these are breaking the tool, splitting the wood, and having the work thrown out of the lathe.

The work having been smoothed down, the difficulties of the tyro may be said to commence, and these difficulties may be classed under three heads: first, turning a true cylinder; second, turning a flat surface, an operation which is usually termed, facing; and, third, working accurately to measurement.

These difficulties may, however, be overcome by an ordinary amount of care, those included under the first and second classes being rendered evident by a due application of the straight-edge, which will show at once which parts require turning down, while the correctness of the work, as regards dimensions, is proved by compasses and callipers, or, in the case of bodies having an undulating outline, by templates, which consist of sheets of metal, or other suitable material, cut out in the form of a counterpart to the profile of the object to be turned; thus, a template for a sphere, or ball, would be made as shown in fig. 30. It is evident that if the edge of this template be chalked, blackened, or otherwise marked with colouring matter, and held against the object to be operated upon with sufficient force while the work is revolving in the lathe, the prominent parts of the object will be marked, thus showing the parts which require to be reduced. The application of the

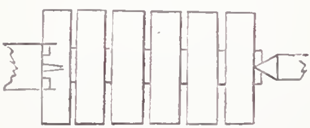
FIG. 30.

the work being turned cylindrical, the support is passed over the end; it is then moved forward occasionally as the work progresses. When the work is to be turned down to its intended form, each short length of the work should be finished, except the polishing, as the operator proceeds, for as soon as the cylindrical form of the work is destroyed the poppet-head is unable to afford any further support.

These handles may be finished according to the directions given for the short ones, and it will also be desirable to take similar means of obtaining handles of a form suited to the hand of the operator.

The next example which we select is the cutting out of blanks for draftsmen, &c. This requires more care and skill than the preceding operations, and necessitates the use of the compasses and callipers.

FIG. 33.



A piece of wood of the required colour is placed between the centres as hereinbefore directed, and reduced to the cylindrical form, having a diameter somewhat larger than that of the intended blank, a number of which, according to the length of the pieces employed, are there marked off by the points of the compasses being held against the cylinder revolving in the lathe, leaving a sufficient space between the blanks for the action of the parting-tool, as shown in fig. 33. It is then cut partially through, an axis

being left of sufficient strength to support the work whilst being finished.

The callipers are now to be set to the required diameter, and to be applied to the work till it is rendered true and parallel, and reduced to the finished size by the chisel. The blanks may then be separated either by the parting-tool, or with a fine saw, and the faces ornamented according to the method given in the instructions for the use of those chucks that are employed for holding works to be faced. We consider the above examples sufficient to initiate the beginner into the use of the prong-chuck and back centre, as all other operations to be performed are so similar to those described as to require no special explanation; it is also desirable for the tyro to be obliged to search out ways and means of accomplishing his objects for himself, whereby he will become more thoroughly acquainted with the actual capabilities of the machine he uses, and he will also by this method allow a greater scope to his ingenuity, and find greater pleasure in his work when it is completed. The next operations to which we turn our attention are those in which the aid of the cup-chuck is required, and we can hardly select a more convenient or more useful object for formation than the cup-chuck itself.

This chuck should be made of box-wood, of which a convenient pieee is to be selected, and a hole carefully bored through it in the direction of its length

(this hole should be of the same diameter as the bottom of the threads on the nose of the mandril in the fixed poppet-head); it is then to be fixed firmly in the vice, or other convenient apparatus, and a tap or long metal screw, with which the turner must be provided, and which will be fully described in a subsequent chapter,carefully screwed into it by means of a tap wrench which fits the top of the top, until it passes nearly through the block. This tap will leave the screw slightly taper; it is therefore made parallel by screwing it on the nose of the mandril. In this position the face of the work is turned either truly flat, or very slightly concave; this being done, it is unscrewed from the mandril, reversed, and again screwed on, so that the turned surface now bears against the shoulder of the mandril, and is perfectly free from all shakiness, &c. The outside may now be formed in the same manner as work between the centres. The T piece of the rest is then brought across or at right angles to the bed of the lathe, at a convenient distance from the work, to support the tools requisite to hollow out the chuck.

As the amateur is somewhat liable to split his cup-chucks, through using too great an amount of force in fixing articles to be turned in it, he will find it desirable to fix a metal ring on the mouth of the chuck, and for the reception of this a slight recess may be turned.

The cavity in the chuck is produced by the side-tool, and when an aperture of sufficient dimensions has been produced by this, the chuck may be finished off ready for use.

It is a very good plan to use these chucks for small work first, as if this be done, when the chucks have become jagged, or are otherwise rendered unfit for further use, they may be re-turned, and used for larger work.

In turning out almost all hollow work, the action of the tool is that of a scraper, as the tool can very seldom be applied at an angle sufficiently acute to present a cutting edge.

We will now proceed, with the aid of our cup-chuck, to complete the draftsmen, the blanks for which have been formed according to the method described at page 53. A chuck of the proper size is to be selected, and screwed on to the mandril, after which a blank is slightly tapped into it with a light hammer. The mandril is then caused to revolve, and a black-lead pencil held against the face of the blank, whereby the prominent side is marked off. The projecting part is then gently tapped with a hammer, and the operation repeated until the blank is found to run true by the pencil marking it equally all round. The chisel is now applied as a scraper at right angles to the face of the work, not tangentially, to produce the required form; one side being completed, the other is operated upon in a similar

manner, and to ensure similarity in the faces, a template, or counterpart of the ornamental surfaces should be formed of tin, or, better still, of steel, and held against the work, after having had its edge coloured to mark out the parts which require turning down, the operation being repeated until the face undergoing the manipulation is accurate.

These, and similar works, may be at once produced by using moulding chisels, which are tools whose cutting edges form a counterpart of the required object; but although much time is thus saved, we strongly recommend the tyro to avoid the use of them, as they are very liable to create a carelessness about measurements, which in complicated works are of the utmost importance.

The cup-chuck is of great use for small works, especially such as require to be turned out hollow.

We will take as another example of the method of using this chuck, the process of turning a sphere ball. First, it is requisite to bring the material to a form approaching that of the required sphere; let it then be placed in a cup-chuck, and reduced to the true diameter, allowing for polishing, &c. At the middle of its length, mark a ring by means of a fine-pointed black-lead pencil; this will act as a guide whilst turning the ends, which are now to be reduced as nearly as possible to hemi-spheres (a metal or wooden template cut out to a semi-circle of the proper size will be found of great assistance).

Now take the ball out of the chuck, and replace it at right angles to its former position; then again apply the pencil, which will mark off the high points, which are of course to be turned down; by thus altering the position of the ball several times, with a little practice a sphere of tolerable accuracy may be produced.

We next proceed to consider the application of the face-chuck, but consider it desirable first to show the method of facing any shoulders, &c., on objects between the centres.

Let it be required to face a shoulder that has already been roughed out by the gouge or point-tool; it may then be done with the turning-chisel, held at right angles to the surface to be faced, and if the shoulder is of considerable width, it will be found the most convenient and satisfactory method of proceeding; the work must, of course, be tested by the square and straight-edge.

If the shoulder is small, the most convenient tool with which to face it is the side-tool.

Flat thin works and such pieces as are too large to fit the cup-chucks are turned on the face-plates. Let it be required to turn a foot for a stand of any description, to which a hole in the centre will not be detrimental.

A piece of wood of the proper size and description having been selected, a small hole is bored in the centre with a gimlet, and the work is then screw-

ed on to the face-plate, fig. 4. This being done, the rest is brought up and the T piece placed across or at right angles to the lathe-bed; the work is then brought roughly to the required form by the means of the gouge or point-tool. The concave parts of the work are now finished off with a fine sharp gouge and the flat and convex parts completed with the chisel, the accuracy of the work being tested, and the high parts pointed out, by the application of a coloured template.

If the object to be turned is of such a nature as to be permanently injured by an aperture in the centre, this chuck is evidently inapplicable.

Let it be required to turn a shallow box and its cover, the latter being intended to be subsequently ornamented. For this purpose we must have recourse to the face-plate shown at fig. 5. The material having been selected and reduced to a convenient form and size is placed against the chuck, and cautiously tapped with the mallet until the four small points on the face-plate take sufficient hold; the back centre is then brought up and screwed against the work to keep it well up to the face-plate; or if the indentation which will be produced by the steel centre be not allowable, a piece of wood must be glued to the work to receive that centre. This being done, the face of the work is first turned down flat, and then the contour intended for the bottom of the box is given to it. For

these processes, the tools which will be found most convenient are the point-tool and the side-tool, and such moulding-tools as the nature of the work may render necessary. The bottom and periphery of the box being finished. the work is to be removed from the chuck, the piece of wood which received the back centre struck off, and the work re ad-justed in a reversed position on the chuck, when it is to be turned out hollow by the gouge and side-tool, enough only being left at the centre to support the work during the operation of smoothing. The box itself being now completed, the cover may be made in a similar manner. For very fine work, or for very hard material, this chuck will not be applicable, and recourse must be had to the cement-chuck.

This chuck is extremely useful for small thin pieces of horn, shell, &c.

Let it be required to produce some small mother-of-pearl blanks, such as are used for making card-players' counters.

A piece of mother-of-pearl of a suitable thickness being selected, it is to be cut up into convenient sizes for the intended blanks. The cement-chuck is then screwed on the mandril-nose and the lathe set in motion; a lump of turner's cement, for which a recipe will be found in Chapter IV., is now held against the chuck, and the friction thus produced will generate sufficient heat to melt the cement. Before the cement hardens, the work is pressed

against it, and becomes firmly fixed to the face-plate.

The work being thus fixed, it may now be faced and turned with proper tools, and when one side is completed it may be detached from the chuck by a smart blow and reversed for the other side to be similarly operated upon.

The next chuck to which we have to allude is the arbor-chuck, one which is very useful for holding such work as rings, small cups, and all kinds of small hollow work, during the turning of their exteriors. If we purpose turning a cup or drinking-horn, for instance, it may first be turned out hollow in one of the cup-chucks, after which it is to be removed to the arbor-chuck whilst its periphery is turned and its end faced.

The only remaining chucks are the spring-cup-chuck, and the spring-chuck for holding hollow work.

These chucks are generally used for light work which will not bear a blow, and therefore cannot be fixed either to the cup or arbor-chuck, but they are used exactly in the same way.

We will take for an example of the use of these chucks the formation of a very thin horn-cup.

A piece of good sound horn is first reduced roughly to the cylindrical form; it is then placed within the spring-chuck, fig. 7, and the ring, *b b*, drawn forward, whereby the work is firmly held. While

in this position, the inside is carefully turned out hollow by means of keen side-tools, and the edge is also smoothed off. The work is now removed from this chuck and placed upon the other spring-chuck, and the plug in the chuck forced forward, whereby the chuck is expanded and the requisite hold on the work obtained. The work may now be completely finished.

All the chucks should be turned on the lathe for which they are intended, otherwise they are almost sure to be inaccurate. As it is very desirable for the turner either to make his own chucks or prove the accuracy of such as he may have made, we shall give instructions for turning all those which we have described, with the exception of the common cup-chuck, for the formation of which directions have already been given.

The strut or prong-chuck consists of two parts, the socket properly called the chuck, and the prong or strut which fits into it.

The chuck is usually made of metal, a casting being made for the purpose. This casting should first be fixed in a metal cup-chuck, which is provided with several set screws for adjusting and fixing the work. While in this position, the cavity within which the screw is to be cut may be drilled or bored out, and that part of the chuck which will rest against the mandril-collar faced either truly plane or slightly concave. The latter is perhaps the

best method. The hole, which is ultimately to receive the tang of the prong, is also to be bored; the work may now be removed from the lathe, unless the screw is to be cut in the lathe, which is decidedly the best plan, and which is to be effected according to the directions given in the chapter on screw-cutting. If the screw is not to be cut in the lathe, the work is firmly fixed in a smith's vice, and while there the screw thread is cut by means of a tap, similar to that mentioned in the instructions for making cup-chucks.

The chuck is now screwed firmly on to the mandril of the lathe for which it is intended, so that the faced surface bears well against the collar of the mandril, and in this position the remainder of the chuck is turned. It is then removed from the mandril back to the vice, and the hole in which the prong is to fit filed out square, when the chuck will be complete. It now remains to make the prong, and care must be taken to have this very accurate—that is, to have the spike or point of the prong truly in the axis, or centre line of the mandril. A suitable forging having been prepared of good steel, the tang is filed down so as to fit accurately the socket of the chuck.

The chuck is then screwed on to the mandril, and the prong forging firmly fixed into it. The centre may then be turned, after which all that

remains to be done is to file up the knife edges, and harden and grind the prong.

We may here observe, that the same tap or screw-tools used in the construction of this chuck will be required for fitting those we are about to describe to the mandril-nose.

The various face-plates should be made of pieces of good hard wood, free from knots, &c. A piece of wood having been chosen, a hole is to be bored at the back of it in the centre, and a screw cut as before directed. The chuck may then be screwed firmly on to the mandril, and the front of it carefully faced, all errors being detected by means of the straight-edge. The front having been truly faced, the back may be also faced, which should be so done that the chuck is left thicker towards the centre than at the edges. Finally, the socket and edge of the chuck may be turned, and the screw or spikes, if such are to be used, carefully fixed in their proper places. The operations to be performed in constructing arbor-chucks are very similar to those employed for the strut-chucks, but great care must be taken to turn the arbor accurate; and the aperture into which the prong fits must be entirely omitted.

The spring-chucks—the only ones of which we have not considered the construction—now demand our attention. These chucks are sometimes constructed in wood, after a similar method to that

employed for the common chucks; but brass tube will be found most satisfactory, and it should be wrought in the following manner: A piece of tubing of the proper length being cut off, one end of it is firmly plugged up with a piece of hard wood, which is carefully fitted to the mandril-screw. The brass tube is then turned inside and out, the inside being made slightly taper, and widest at the mouth, if it is to be used as a cup-chuck; but the outside is to be made taper, and largest at the end nearest the poppet-head, if the chuck is to be used as an arbor-chuck.

The chuck being turned and bored, a number of holes are to be drilled through the brass tube, and from these cuts are to be made with a saw up to the mouth of the chuck, whereby the chuck will be rendered elastic.

If the chuck is to hold solid work, it should be furnished with a ring, which, by being slid forward, will cause the chuck to grasp the work firmly. If the chuck is to hold hollow work, it is provided with an internal plug, which, by being slid forward, expands the chuck, and causes it to fit the work tightly.

It is always desirable to economise material to the greatest convenient extent, and by so doing time may also frequently be saved. The following are a few examples of the numerous methods by which this double object may be obtained:

Let it be required to turn a cylindrical box, then the most expeditious method of doing it will be as follows: — First plane the bottom of the intended box smooth and flat, then fix it in the cup-chuck. This being done, cut with the straight parting-tool a groove of the proper diameter, and of a depth equal to the depth of the box; then make a hole in the centre of the work, and with a side parting-tool remove the annular piece of superfluous material remaining, as shown at fig. 34. The outside of the box may then be turned in any convenient manner, and also the cover of the box. By these means we save a ring of the material of which the box is made, which may serve for other purposes.

Fig. 34.

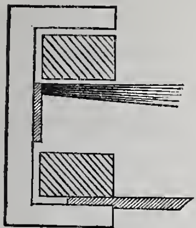
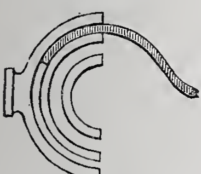


Fig. 35.



Let there be required a number of money-bowls of various sizes, as shown at fig. 35. A piece of wood having been selected and planed at the bottom, it is to be fixed on the face-plate, and the exterior of the largest bowl turned. Then, by using a properly formed parting-tool, the whole of the internal part of the work may be removed entire, from which smaller bowls may be made.

It is unnecessary further to multiply examples, as

those already given will be found sufficient for the guidance of the student, who will in future immediately recognise such cases as will admit of being thus treated. We consider that the instructions already given will be sufficient to enable the amateur to perfect himself in the use of the common chucks, and the tools with which they are associated.

There are several kinds of more complicated chucks, but to give a full description of them, and of the method of using them, would far exceed the limits of the present work, which is intended to be entirely elementary. We shall, however, in a subsequent chapter show the application of one or two of the most simple of them, in order that the tyro may be provided with the necessary information for producing certain simple ornamentations on his work, whereby to vary the effects producible with the ordinary apparatus.

CHAPTER IV.

DRILLING, ETC.

The process which we are now about to describe is one of the most important processes of mechanical manipulation, not only on account of the accuracy of many machines depending entirely upon those parts which are bored, but also from the great variety of purposes to which it is adapted.

Under this head, then, we shall include drilling, boring, broaching, and some varieties of turning and carving.

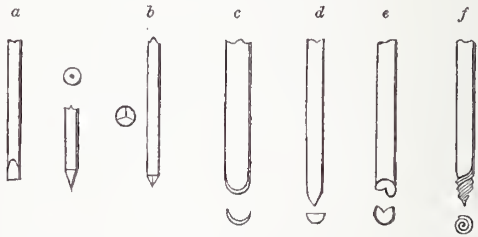
Drills may be classed under three distinct heads: first, drills for wood and soft materials; second, drills for metals and hard materials; and third, drills for carving or otherwise producing an ornamental surace.

These three classes of drills we shall consider in the above order, after which we shall turn our attention to the form and use of broaches, and also of those instruments which are used to obtain a true cylin-

drical or other hole, the hole having been previously drilled, which apparatus are termed "boring-heads."

We will now proceed to the consideration of those tools which are included in the first class.

Fig. 36.



These drills, or rather those of them which are most generally used, are represented in fig. 36.

The brad-awl, *a*, is by far the most simple; it consists of a chisel-pointed cylindrical piece of steel wire, fitted to a handle; it acts partly by cutting away the material through which it is made to penetrate, and partly by displacing it; it is worked by imparting to it a reciprocating circular motion.

b represents another form of awl, which has three facets ground upon its end, forming a pyramidal point.

The awl used by wire-workers, such as bird-cage makers, &c., is square and sharp on all sides. Most instruments used in carpentry for boring are fluted in order to give room for the shavings to escape.

The shell-bit, also called the gouge-bit and quil-bit, is represented at *c*.

It is sharpened at one end, like a gouge, and, when revolving, it shears the fibres of the wood round the margin of the hole, and removes the wood almost as a solid core. Very small tools of this description are sometimes used for boring holes in the backs of brushes.

The spoon-bit, which is shown at *d*, is generally bent up at one end, so as to make a taper point. It acts something like the ordinary pointed drill, but it is furnished with a keen edge suitable for cutting wood.

The cooper's dowel-bit, and the table-bit for boring the wooden joints of tablcs, are of this kind. When the end of this drill is bent into a semi-circular form, it is called a duck-nose-bit, on account of its form, and also a brush-bit, from the use to which it is applied.

At *e* is represented a drill called a nose-bit, slit-nose-bit, or auger-bit.

It is slit up a small distance near the centre, and the larger piece of the end is then carefully bent up at nearly right angles to the shaft, so as to act like a paring-chisel. The corner of the reed near the nose also cuts slightly.

When made of a large size, this tool is called the shell-auger, and is sometimes made three inches in diameter and upwards, with long movable shanks for boring pump-barrels, &c.

Before using nose-bits, a preparatory hole must

be made with a brad-awl or centre-punch. With augers a preparatory hole is always made with either a centre-bit or gouge of the same size as the auger.

The gimlet, which is represented at *f*, is also a fluted tool. It consists of a semi-cylindrical shell, which is terminated by a sharp conical screw.

The action of this tool is as follows: it is turned into the material by a cross handle at the top of the shaft, and the conical screw having once taken hold of the material, it alone is sufficient to draw the tool through the material. The sides of the flute are also ground to a keen edge, so as to act by cutting away the wood as the tool progresses.

Thus we see the material, while being bored, is first compressed by the action of the screw, and then cut away by the sharp sides of the tool.

When the shell is full of wood, the gimlet is withdrawn and emptied. In cutting hard wood the core thus removed will sometimes come away as a solid mass or cylinder.

Fig. 37.

The centre-bit, which is represented in the accompanying fig. 37, is one of the most useful boring tools with which we are acquainted. It consists of three parts, viz. a centre-point or pin, which retains the bit in its proper position, and enables the operator to determine accurately the position of the hole; a thin shearing point, or nicker,

which is plcced at a distance from the centre-point equal to the radius of the hole, and which cuts away the material from the sides of the hole, thereby leaving them smooth and true; and a broad chisel edge or cutter, which extends from the centre-point of the bit nearly to the side of the hole, and which acts by cutting away the material that has been severed from the sides of the hole by the nicker. To accomplish this properly, it is evident that the chisel edge should have less length and less radius than the nicker.

There are many forms of centre-bits in use, but to describe them all would far exceed our limits. We have therefore considered only the common form of this class of drill.

Various forms of augers are made with spiral stems, so that the shavings may ascend the hollow worm and thereby avoid the inconvenience of withdrawing the bit so frequently as is necessary when using any of the fluted bits.

The twisted gimlet is a tool of this sort. It is made with a conical stem, round which is filed a spiral semi-circular groove, one edge of which is thus sharpened, and thereby serves to enlarge the hole, and the instrument progresses through the material. In the use of this tool there is also less risk of splitting the wood which is being operated upon than that incurred by the employment of the common gimlet, which requires to be used with great caution upon wood which is at all liable to split.

The common screw auger is forged as a parallel blade of steel and twisted into a spiral form while redhot. The end terminates in a conical worm, by which the auger is gradually drawn into the material which is being bored.

A similar kind of shaft is sometimes made, having a plain conical point, above which are two scorers and two chisel edges, forming, in fact, a species of double centre-bit.

The various kinds of boring-bits are usually set in motion by means of the carpenter's brace, shown at fig. 38.

FIG. 38.

This brace is made in the form of a crank, as shown.

The bit, which is made with a taper square-topped shaft with a nick near the end of it, is inserted into a square socket shown at *a*, and retained in its place a spring which drops into the nick of the boring-bit. When the bit is to be removed from the brace, it may be released by pressing a stud in one side of the socket, which forces the spring out of the nick.

The upper end of the brace is fitted into a swivel or shield, through which the requisite amount of pressure is transmitted from the operator's chest while the bit is in action.

Augers are usually moved by transverse handles.

Some augers are made with shanks and riveted into their handles like common gimlets, but the

common practice is to form the end of the shaft into a ring or eye, through which the handle is tightly drawn.

Those tools which are worked alternately in each direction and require only a slight application of force, such as the common brad-awls, are usually made with straight handles.

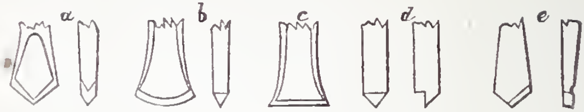
We will now conclude our account of the first class of drilling tools, but it may be well, before taking leave of the subject, to direct the attention of the amateur to a source whence he may possibly obtain some important information with regard to boring apparatus for working in wood.

The source to which we refer consists in a careful examination of those instruments with which nature has provided the various wood-boring insects, as these must necessarily be most applicable to the purposes for which they are intended, the only difficulty being the conveniently forming these tools, as many of them are somewhat complicated.

We shall now direct our attention to the second class of drills, viz. those used for boring holes in metal, ivory, and other materials, which are too hard to admit of the satisfactory application of those tools which we have already described.

The drills used for operating upon hard materials usually have their edges somewhat more obtuse than those of the tools used for soft wood.

Fig. 39.



In fig. 39, we represented various forms of the common kind of drills.

a is a type of a very important class of drills; they are made of all sizes and for all kinds of materials. The two cutting edges make an angle, which varies according to the hardness of the material for which it is intended, being more obtuse for hard than for soft work.

These drills are worked in one of two ways, either by rotating them continually in one direction, or by giveng them a reciprocating rotatory motion.

If the drill is to be worked according to the last method, the two cutting edges will have four facets ground upon them, two for each cutting edge, as shown in the figure.

The angle contained between the two facets of one cutting edge should be about 70 or 80 deg., and the angle contained between the cutting edges may be about 90 deg.

In small drills of this description it will be advisable to make the angle contained between the cutting edges as large as 120 deg., to prevent the point of the drill from protruding through thin work long before the

aperture is completed, as by the occurrence of this the drill is caused to shake or chatter, and also to catch in the edges of the orifice and therbey produce rough and unsightly work.

For the same reason it is also desirable to avoid having a longer shaft to the drill than is absolutely necessary.

When the drill is intended to revolve in one direction only, the cutting edges must be differently arranged, and these drills are usually so constructed that the edges actually cut the material away instead of removing it, by scraping, as is the case with the instrument we have just described.

The proper form for the continuously revolving drill is shown at *e*, and it is very similar to the third part of the common centre-bit doubled.

It consists of two chisel edges, including a very considerable angle between them, usually about 140 to 150 deg.; these chisel edges act tangentially to the material to be removed, paring it up from the bottom of the hole.

The cutting edges having been once formed, are sharpened when necessary by grinding the bottom faces of the cutting edges, and they are usually made to contain an angle of from 60 to 80 deg.

When used with malleable metals these drills should be supplied with oil or other lubricant.

In making these drills, care should be taken to make the cutting part of the drill a little wider than

the diameter of the shaft of the drill in order that it may clear the sides of the hole, but it should not be made much wider, or it will be very liable to shake.

The drills should be hardened in the same manner as the other cutting tools, and then tempered down to a dark straw yellow colour.

b represents another form of drill intended to be worked with a reciprocating motion.

The edge of this drill, instead of being formed by two straight lines including an angle, is circular, as shown.

The cutting edge is made of the same angle as that of the foregoing drills; it is formed by grinding a chamfer on each side of the drill.

This drill bores cast-iron and many other materials with greater rapidity than any other kind of reciprocating drill.

As this tool will not bore with any amount of accuracy, at least as far as the position of the centre line or axis of the hole is concerned, it will be found necessary to commence the hole with one of the pointed drills, after which it may be completed with the circular edged tool.

The holes produced by the ordinary drills will, in every case, be conical at the bottom, provided it does not extend through the entire thickness of the material; in this case it will frequently be found necessary to make the bottom of the hole flat for the reception of the flat end of a rod or other piece of

work, and to produce the flat bottom to the hole it is necessary to make use of a drill with a perfectly straight edge.

This drill is represented at *c* in the figure; it may be worked with a reciprocating motion, and is furnished with a cutting edge, whose facets contain an angle equal to that employed in the construction of the other drills.

d represents another form of drill; it is made of a cylindrical rod with the end turned down to a cone, of which half is afterwards cut away, leaving a sharp edge containing an angle of 90 deg.

These drills are not used for cylindrical holes generally, but are confined to the boring of conical holes, which are commonly called countersunk holes.

These countersunk holes are required for a variety of purposes, such as for the reception of screw-heads, and for the recesses in the ends of work to be supported between the lathe centres.

Before commencing the drilling of any hole the position of its centre should be marked with a centre-punch, so as to form a guide for the point of the drill when it begins to cut.

Having thus briefly described types of the various forms of drills used for both soft and hard materials, it now remains to show by what means they are applied to the various purposes for which they are designed.

We will commence with the smallest drills and proceed towards the largest.

The smallest drills which are commonly made are those employed by the watchmakers for boring the holes and bearings required in their delicate and beautiful work. They are made from a piece of good steel wire, which is tapered down at one end, hammered out flat on an anvil, and then filed up to the requisite form. They are then hardened; but the ordinary method of hardening and tempering is inapplicable to these small tools, as they would not retain their heat sufficiently long to enable the operator to remove them from the source of heat to the trough containing the water for hardening.

The method employed in hardening these small tools is this: the instrument is heated in the flame of a candle, and hardened by plunging it suddenly into the grease of the candle.

The reverse end is now made into a conical point and hardened. This conical point is, when the drill is in use, placed in a countersunk hole in a breast-plate, by means of which it is supported and pressed against the work to be drilled.

The shaft of the drill is now fitted with a small brass pulley, or sheave, which is fixed upon it at a short distance from the conical point at the tail of the drill.

Around the above sheave is passed the line of a bow, by which the drill is caused to revolve. For these very small drills the drill-bow may be

made of a horsehair, stretched upon a piece of whalebone.

As the drills increase in size the bow also increases; for larger drills the bow may be made of the half of a solid cane about one inch diameter, and two feet six inches in length, or it may be made of a piece of steel, with a hook at one end, and a ratchet wheel with a small barrel attached to it, upon which to wind the surplus thread.

The best material of which to form the bowstring is catgut.

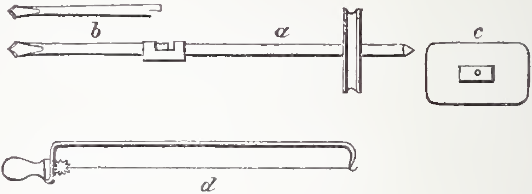
The same breastplate may be made to serve with a great variety of drills, by means of furnishing it with countersunk holes of various sizes.

It is evident that the above method of constructing drills would necessitate the formation of as many sheaves, and as this is somewhat inconvenient in larger drills, it is avoided by the adoption of an apparatus called a drill-stock, in which the various drills may be fitted as required.

The commonest form of drill-stock is that which is formed to be used with the breastplate and furnished with a sheave, having in fact all the parts of the common drill except the point, and this is replaced by a hollow cylinder, beyond the internal hollow of which is a half round hollow, to which is fitted the tail of the drill which is to be used.

This drill-stock and the manner of fitting the drill to it is shown in the subjoined figure.

Fig. 40.



In fig. 40, *a* represents the ordinary drill-stock furnished with a grooved pulley, centre, and socket.

b represents two similar drills, one within the drill-stock and the other separate.

c represents the ordinary breastplate; it consists of a slightly curved iron plate, upon which is fixed a small square piece of steel in which is drilled the countersink.

d is the steel bow and string.

This apparatus will be found, perhaps, the most convenient form that can be adopted, where a large number of holes are required to be drilled which do not exceed three-sixteenths of an inch in diameter. There are, however, other forms of drill-stock which will be found exceedingly convenient for producing small holes, where only one or two are required at a time. Its principal advantage consists in its always being ready for use, whereby the delay caused by adjusting the bowstring to the sheave on the foregoing stock is avoided.

The stock to which we refer consists of a shaft about fifteen inches long upon which is cut a screw of very steep pitch; this shaft is caused to revolve by moving a nut upon it in a vertical direction without allowing the latter to revolve, which is accomplished by means of a short handle, one end of which is made into a fork to embrace the nut, to which it is fixed by points or centres.

It is evident from the above that by moving this handle rapidly in a vertical direction we impart the required motion to the shaft, namely, a reciprocating circular motion, and if the shaft be fitted at the upper end into a swivel, and be provided at the lower end with a socket for holding the drills, the apparatus will be complete.

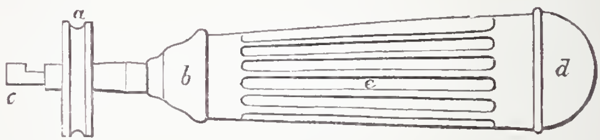
As some operators consider, and not without reason, that the most expeditious drills are those which revolve continually in one direction, a movement of which the generality of small stocks will not admit, a modification of the above contrivance has been produced to supply this want.

The shaft and swivel of this stock are in all respects similar to those of the foregoing, as is also the nut and handle, but the socket is attached to the shaft by means of a ratchet-wheel and spring which allow the drill to revolve in one direction only; the shaft is also furnished with a heavy fly-wheel, whereby the motion is kept up after each stroke, during the return of the driving-nut to the top of the shaft.

The class of stocks which we have just described, although more convenient than the older form of drill stock, possesses the disadvantage of being not so durable; we therefore think it desirable to furnish our readers with a description of the most compact form in which the principle of the former apparatus has been embodied.

The instrument of which we speak is about eight inches in length, and intended to be held in the left hand of the operator when in use.

Fig. 41.



This stock is represented in the accompanying figure: it consists of a hollow handle, *e*, furnished with a screw cover, *d*, in which may conveniently be kept a number of drills of various sizes. The other end of the stock is fitted with a gun-metal cap, *b*, upon which is formed a swivel to receive the end of the socket-shaft, *c*; upon this shaft is firmly fixed a gun-metal sheave, *a*, upon which the string of the bow is to be geared when the apparatus is required for use.

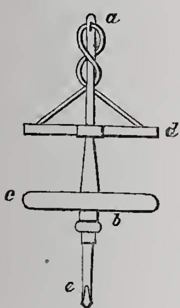
This apparatus is highly recommended for its compactness, durability, and ease of application; all that

is necessary for its manipulation consisting in the working of the bow with the right hand, while the drill is firmly held in the left hand against the article to be perforated.

This stock can of course only be used with those drills which are constructed to cut in both directions.

We think it desirable, before taking leave of the small drill-stocks, to give a description of the Chinese stock, although that instrument is not in very general use.

Fig. 42.



The annexed figure is a representation of the Chinese drill-stock; *a b* is the shaft, which is formed with a socket at the bottom for the reception of the drill, and the upper part is formed into a ring or eye. Upon the shaft is firmly fixed a heavy fly-wheel, *c*, and through the eye is passed a thong of flexible leather, the two ends of which are attached to the cross-bar, *d*, through which the drill-shaft freely passes. The method of using this drill-stock is as follows:

A drill of the proper size having been fitted into the socket, and the point thereof rested upon the work to be perforated, the operator takes hold of the cross-bar with his right hand, while he twists the drill round with his left, the effect of which is to coil the

thong around the shaft as shown in the figure; he then releases the shaft, and presses heavily on the cross-bar, whereby the thong is uncoiled, and the shaft caused to revolve rapidly. At the end of the stroke the pressure is removed from the shaft, and the momentum imparted to the fly-wheel coils the thong upon the shaft in the opposite direction to that in which it was first coiled. By repeating this process a rapid reciprocating motion of the drill may be maintained. The top of the shaft may be fitted to a swivel or other convenient apparatus to enable the operator to retain the drill-shaft in a vertical direction. This stock is chiefly used for drilling china, and similar articles, the drills used being made in the form of a tube, to the end of which a diamond is attached, which diamond, when the apparatus is in use, must occasionally be moistened. Having now described most of those stocks by which the small varieties of drills may most conveniently be worked, we will proceed to the consideration of the means by which the larger drills are applied to the purposes for which they are designed.

Drills of all sizes may conveniently be used in the lathe, by being fixed in a small square hole chuck, the drills being made with square tangs, and when great accuracy is required this method will be found very satisfactory and expeditious. If the object to be bored is short in the direction of the axis of the hole to be bored, the drill should be fixed in the proper chuck,

and the work pressed against it by the back centre; if the hole is to be bored through the entire thickness of the material, a block of wood should be placed behind it to serve for the centre to rest against, and also to prevent the danger of breaking the drill, which is very considerable during the period which elapses from the time when the point of the drill appears through the material until the hole is completed. If the work in which the hole is to be drilled is long, the hole being in an axial direction, one end of it should be fixed in a suitable chuck, the end which is to be bored being supported in the boring collar, and the drill fixed to the back head of the lathe. In this case the work will, of course, revolve, the drill remaining stationary. The drill is usually supported by the back centre entering a countersink in its tang, the point resting in the work, and the drill being prevented from revolving by a bar being clamped to it, which bar rests against the lathe-bed.

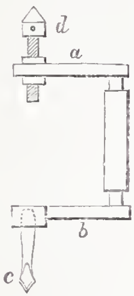
The drilling lathe, which may be used for all kinds of drills and broaches, being made especially for that purpose, is usually a diminutive lathe, the bed of which consists of a triangular steel bar fixed with its edge upwards; upon this, front and back poppets, made in gun-metal, are fitted, and also a slide rest.

The lathe-bed is fixed upon standards, and furnished with a treddle and fly-wheel, as in the ordinary foot-lathe.

For drills above a quarter of an inch in diameter, a

stock is used, which is very similar to the carpenters' brace: it is represented in the annexed sketch.

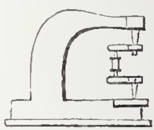
Fig. 43.



In fig. 43, *a b* represents the crank of the brace; at one end it is bored and tapped; and at the other fitted with a square socket for the reception of the drill. The crank has a sheath round it to allow of its being worked with convenience.

The point of the drill, *c*, being placed upon the work to be perforated in the proper position, and the centre at the end of the set-screw being rested against a countersunk hole in a suitable position, the pressure is applied through the elasticity of the brace, which is maintained in a state of tension by occasionally tightening up the set-screw. This apparatus may be very conveniently used with the apparatus shown in the accompanying figure: *a*, is the plate in which the countersunk hole is drilled; and *b*, the table whereon to lay the work.

Fig. 44.

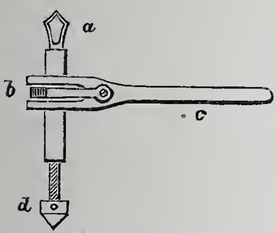


A similar clamp may also be used to attach to large objects which are to be drilled. Although the above brace, and also those which follow, are used almost entirely for working in metal, and are therefore out of the category of tools required for the processes of which we treat, we have, nevertheless, thought it desirable to complete the

subject with which our attention is at present occupied.

The apparatus which we are now about to explain, has for its object the continual rotation of the drill in one direction, although the brace itself cannot be made to perform one complete revolution.

Fig. 45.



The apparatus of which we speak is called a ratchet-brace, and is usually of the form shown in fig. 45: *a*, is the socket on the drill-shaft, within which the drill is fitted.

Upon the centre of the shaft is fixed a ratchet-wheel, *b*, embraced by the forked end of the lever *c*; upon the lever is fastened a strong spring, which forces the wheel before it when the lever is moved in one direction, but slides over the teeth upon the return of the lever.

The tail end of the stock is furnished with a capstan-headed set-screw carrying a centre, the feed being given to the drill by turning the screw gradually out of the shaft.

Drill-stocks are sometimes constructed similar to the above, but fitted with a spherical motion at the end of the lever *c*, to allow of its being worked in any required position.

It may occasionally occur that a hole is required to be drilled at the bottom of a recess which is too deep

to be reached by the length of the drill, and at the same time not sufficiently large to allow of the introduction of the drill-brace; the difficulty must then be overcome by the use of some such contrivances as those represented in the following figure.

Fig. 46.

These tools consist of shafts having a square socket at one end and corresponding tang at the other.

When used, one of the lengthening pieces is fitted into the stock, and as many more as may be required are fitted to that, the tang of the drill being fitted into the socket of the last lengthening bar.

We now proceed to the consideration of the third and perhaps most interesting section of this chapter.

In the foregoing pages we have treated fully of the form, material, and various methods of application of those numerous tools which are designed to produce cylindrical apertures in wood and metal; these apertures being intended either to lighten the work or for the reception of the bolts, screws, or pins, by which the various parts of the entire work are held together, or to be ultimately bored for the reception or guidance of moving parts. In the following pages we purpose also to describe the form and application of various borers. somewhat similar in their mode of action to the foregoing, but designed to effect a totally different result.

The object of these drills is to produce various

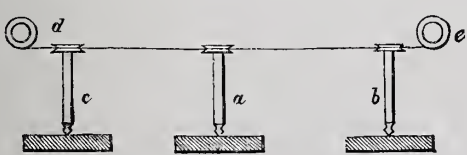
carved surfaces, either for ornament or use, and their general principle may be explained in the following manner.

If we suppose a drill to have a semi-circular cutting edge, and cause this drill to cut any material until it has reached a depth equal to the radius of the cutting edge, we shall thereby produce a recess which is the counterpart of a hemi-sphere, and if we cause the drill to cut a great number of these hemi-spherical recesses in very close proximity to each other, we shall, by such means, obtain a groove of semi-circular section.

The tools by which these grooves are produced in practice bear more resemblance, as far as regards their principle, to rotatory cutters than to drills, the cutters varying in form according to the section of groove which the manipulator may desire to produce.

This principle has been worked with great advantage in an apparatus known as Jordan's wood-carving machine, by means of which the wood carving in some of our most important cathedrals has recently been executed; all that is necessary by way of a guide being one carving, of which the machine will produce any required number of copies.

Fig. 47.



We will endeavour to explain the principle of this machine with the assistance of the accompanying figure.

a represents a piece of wood which is already carved to the required form, and over which is a shaft with a smooth end attached to a frame, which also carries a number of drills or rotatory cutters. This frame is so arranged as to be capable of shifting easily in a vertical direction, but is prevented from moving in a lateral direction by means of suitable guides.

The prepared blocks of wood, *b*, *c*, are placed under the cutting-drills, in the same position relative to them which the copy, *a*, has with regard to the tracer, or blunt drill. These drills are maintained in a state of rapid rotation by means of a small cord, or band, which passes round pulleys attached to the shaft of the drills; this band is represented in the figure by line *d e*.

The copy, *a*, and also the various blocks which are intended to be engraved, are firmly secured to a table, which admits of being moved in any direction by means of the following arrangement: To the bottom of the table are attached various carefully turned pulleys, with grooves on their circumference; these pulleys fit upon rails on a frame similarly fitted, but capable of moving in a direction at right angles to that of the upper table.

It is evident that by means of these rectangular movements, used both separately and combined, the

table may be made to describe any straight or curved line of the pattern.

The following is the manner of working this apparatus: The copy and the blocks which are to be engraved being firmly fixed upon the table, and the drills and tracer properly adjusted, so that when the bottom of the tracer is resting on the highest part of the pattern the points of the drills, or cutters, are in exact contact with the surfaces of the blocks to be engraved, the machine is now to be set in motion, and the drill-frame allowed a free vertical play. The manipulator now moves the table in such a manner that the point of the tracer passes over every part of the pattern; then, as the tracer sinks into the hollows of the design, the frame will also subside through an equal space, and thereby cause the drills to cut an exact counterpart of the hollow which is passing under the point of the tracer upon each block of wood in the machine.

By this means it is evident that we may copy a great many varieties of wood carving, the chief difficulties with which we have to contend consisting in the production of undercuts.

Although the apparatus we have just described will not be required by the amateur, we have yet deemed it desirable to give this brief description of its powers, not only on account of the similarity which the process bears to those we are about to describe, but also in the hope that it may furnish

the means for devising some similar apparatus which may be worked in connexion with the ordinary foot-lathe, whereby the operator may be enabled to reproduce certain ornamental forms, which could not be obtained otherwise without having recourse to the assistance of that complicated and expensive in-instrument, the geometric chuck.

We must, however, now pass on to the consideration of those matters which more immediately concern us, and which, in the present instance, include the various methods of drilling patterns by means of templates.

The principal points which we have to consider are, the best manner of forming the cutting edges, and the means by which the drill is prevented penetrating into the material. A very obvious method for accomplishing the last-mentioned purpose immediately offers itself in the formation of a shoulder upon the drill, which will press against the work as soon as the drill has penetrated to its proper depth, thereby preventing it from injuring the work in hand.

The point now remaining to be considered is the means of ensuring the accurate form and position of the various lines in the pattern being truly transferred to the material on which it is required to engrave it. This may be conveniently accomplished by means of a template cut to the required form, and clamped upon the work in its proper position

by any suitable means, which template will also afford an abutment for the collar of the drill.

If a great number of carvings of the same pattern are required, the template should be cut from a sheet of good steel and properly hardened, which will form the most satisfactory guide on account of its firmness and durability. If, however, but a few carvings of one pattern are required, if will be sufficient to form the template from sheet iron, brass, or copper.

When the block is tolerably thin, and the device is to be engraved on its largest surface, the back poppet of the lathe must be furnished with a drilling-blank, which is very similar to a face-plate, differing from it only in these particulars: it has neither screw nor spikes, and is fitted to the mandril of the back poppet by a circular tang, similar to that attached to the centres.

When, on the contrary, the device is to be cut upon the edge of the work, a block of wood of the required height should be fixed to the lathe-bed, so as to form a table for the support of the work to be operated upon, or otherwise a piece of wood having a circular stem is fixed in the slide in the place of the T piece.

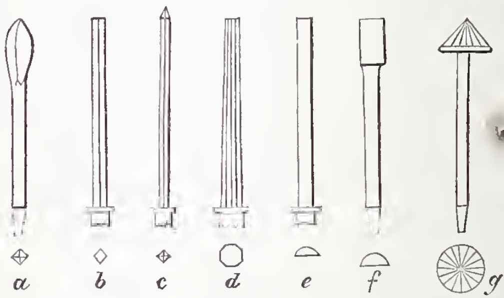
The drills used for this purpose must be carefully made so that their edges may be accurate, otherwise the work produced by these tools will not be satisfactory.

We shall not dwell longer on this subject, as the

process is exceedingly simple, and only requires care. The fourth section of the present chapter, namely, that upon broaches and rimers, is that upon which we are about to concentrate our attention.

The object intended to be gained by the use of these tools is the production of smooth and true cylindrical or taper holes.

Fig. 48.



In fig. 48 we have represented a number of broaches of the forms most generally used. That shown at *a* is square in section, of short length in the cutting part, of about an inch or an inch and a half, pointed, and of varying thickness. This tool is principally used for broaching out holes in plates and other thin materials that require to be considerably enlarged. It may be used for both wood and metal. The angles of the cutting edges are evidently 90 deg., and their action is entirely that of scraping.

b is the figure of a square broach of greater length

than the last mentioned; it is very slightly tapered, and may be used for long holes which are required to be nearly cylindrical, such as those passing through the axis of the bobbins used for silk machinery, and in which holes the quills upon which the bobbins run are placed.

c is a more taper form of broach, and is provided at the end with a pyramidal point whereby it is enabled to bore a hole, and at the same time to rime it out. This tool is that employed by wire-workers, such as bird-cage makers; it is therefore necessarily of small dimensions. The angles of this and those of the last-mentioned broach are the same as those of *a*.

d is the representation of an hexagonal broach: the scraping edges of this tool have a very obtuse angle, namely, 120 deg. It, however, although acting somewhat slowly, is very suitable for hard woods, as it produces a polished surface.

The next tool of which we treat is the half-round broach shown at *e* in the figure. This cuts instead of scraping, and acts with some rapidity, but on the whole we do not think that it is as suitable for wood working as the square or hexagonal rimers.

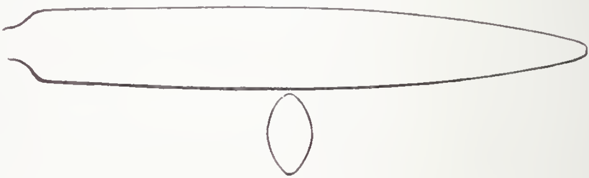
Another form of this instrument is shown at *f*, and this latter is that used chiefly for trueing cylindrical holes of considerable dimensions which have previously been bored in metal; it is seldom or never used except in the latter.

At *g* is a form of tool commonly called a rosebit but we may evidently consider this as derived from

a many-sided broach, for if such a broach have grooves filed in it, and be supposed to be exceedingly taper, we immediately obtain the rose-bit. This bit is used for riming out countersunk holes.

This concludes our brief description of the commonest forms of broaches. They are usually fitted with wooden handles, but they may, nevertheless, be made of such a form as to be conveniently used in a square hole chuck.

Fig. 49.



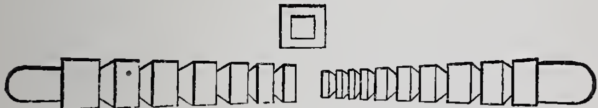
There is another tool in common use which is derived from the broach, which it may not be amiss here to describe. In the above figure it is represented in front and side elevation. It may be said to consist of a piece of steel, whose section is composed of two arcs of a flat ellipse, which, meeting and intersecting on either side, form a very obtuse scraping, or perhaps more correctly speaking, rubbing edge. This tool is called a burnisher, and by its means bright surfaces can be produced on all manner of work.

These tools—both broaches and burnishers—are made of various sizes, and in some cases they seem

to be indentical, each performing that operation for which the other is designed. The smallest are those required by the occupation of the watch and chronometer-maker, corresponding in size to the miniature drills used by that operative.

It is evident that the tools above mentioned are altogether unfitted for the production of true surfaces in any holes except such as are of circular sections; if, therefore, we wish to clear a square hole, or other whose section is bounded by straight lines, we must have recourse to another form of tool.

FIG. 50.



In the accompanying figure we have given three views of that kind of tool which is generally used for clearing those holes whose sections are trigonal, quadrangular, or polygonal. These tools are called drifts, and somewhat resemble a file of which the teeth have a very great depth.

The drifts are thus made: A piece of good steel having been forged to the requisite shape, somewhat taper, it is to be brought to a true form; if for a square hole, the sides may be planed, shaped, or filed up, and this being done, triangular grooves

must be cut or well filed, as shown in the sketch, by which to produce sharp cutting edges with an angle containing about 90 deg.

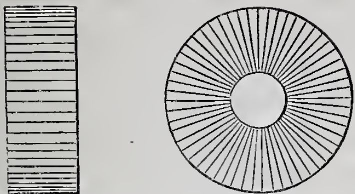
These tools are thus used: A hole being drilled, which it is desired to square, it is first filed out with a file of suitable section, until nearly the form and the size which is required, and this being done, the point of the drift must be placed in the hole in a vertical position; it is now driven through the whole length of the hole by the blows of a hammer.

In hardening these tools great care must be taken, after they are heated, to plunge them into the salt-water tank, for if this be not properly conducted, the drift will be curved, and this defect, though it may be but slight, will prevent the tool from producing true work, and there is a great liability of breaking the drift in use.

We now will describe a species of tool the object of which is the trueing of work of various shapes. It may scarcely be thought that this kind of work should be considered in this chapter, but the discussion of drills, especially those intended for producing ornamental devices, is so nearly allied to that of the cutters we are about to describe, we cannot but think this the best opportunity for explaining their action.

Their object is this—the cutting of nuts and of other articles bounded by small plain surfaces.

FIG. 51.



Two elevations of a rotatory cutter are shown in fig. 51. These are provided with two cutting surfaces, by which we intend two surfaces covered with numerous cutting edges; these two surfaces are the periphery and the annular surface shown in the figure. In the centre of the cutter is a cylindrical hole through which passes the mandril, on which the cutter is retained by a nut. These cutters may be made of various forms, if small, of good steel, to be subsequently hardened; but when they are large this last operation would not be devoid of the danger of splitting the tool; therefore, in this case the tool should be made from the best wrought-iron, and finally case-hardened by one of the following methods:

The commonest method of hardening wrought-iron is by heating it for several hours in an air-tight box, packed full of leather chips, previously carbonised by heating in a close vessel. The materials from which these ashes are obtained, usually worn-out leather boots, the calcining of which is performed in a flat

iron pan fitted with a cover, and as the contents become heated to redness, the pan is occasionally removed from the fire, and its contents pulverised by means of a hammer; when the whole of the leather is reduced to a powder it is ready for use.

The principle upon which this process hardens the iron is by converting the metal a small distance inwards from the surface of the work into steel, which may then be hardened in the ordinary manner, but it will not require the process of tempering, as the iron in the centre imparts sufficient strength.

A more rapid method of case-hardening work, and at the same time proportionately less satisfactory, as regards durability, is the following:

The work to be case-hardened having been raised to a red-heat, it is then sprinkled over with, or otherwise buried in ferrocyanide of potassium, commonly known as the prussiate of potash.

This method imparts a very thin coating of steel to the work—thinner, in fact, than ordinary writing-paper—and it is even by some said to be discontinuous.

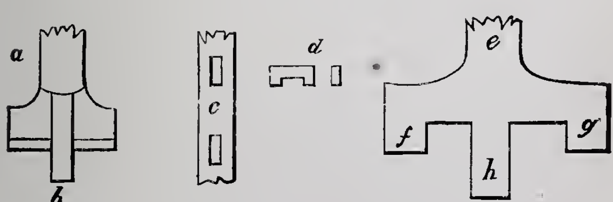
This process, like the last, imparts to the metal some particular elements; it was formerly thought that the only constituent yielded up to the iron in the formation of steel, was carbon, thereby producing a carburet of iron; but it now seems more probable that nitrogen also is combined with the metal, the final result being cyanide of iron, which, in fact,

has been proved very recently by an analytical chemist, who was successful in obtaining steel by passing certain gases, capable of yielding cyanogen, over the metal under circumstances peculiarly favourable to the combination of the two.

Let us now call the attention of the reader to that class of tools, the object of which is the trueing of holes, and also enlarging them when their size is too great for the application of broaches.

These tools may be said to consist of two classes; those in which the cutters are fixed on to a bar, without the interposition of any other apparatus, and the other, wherein the cutters are fixed in a truly turned disc, which fits on a bar; and of this latter class, as they are only applied to large metal works, we shall not consider their principles further, but merely observe that the disc above mentioned is technically termed "a boring head," and also the bar, "a boring bar;" this latter is fitted with a screw in a slot, by means of which, as the boring bar revolves, the head is caused to progress along in the direction of tha length of the bar.

Fig. 52.



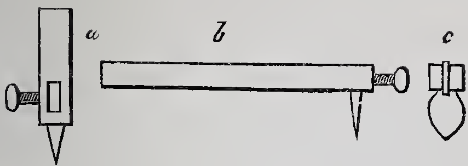
In the accompaniyng figure we have shown a few forms most commonly used for small boring tools. The first, that at *a*, is very convenient for drilling true holes of moderate dimensions and not of very great depth. It consists of a guide in the form of a pin, shown at *b*, and this pin fits into a hole previously drilled; on each side of the pin is a sharp cutting-edge, the whole somewhat resembling, in its principle of action, a double centre-bit, without any nickers.

At *c* is a boring bar, in which are cut slots, into which are inserted small cutting-tools, which are retained there by wedges. The form of these tools is that shown at *d*. This tool is very useful for boring long cylinders, such as that in the back poppet-head of the ordinary lathe, and the manner of using it is detailed below.

The boring bar is fixed between the lathe centres, passing through the cylinder which is required to be bored, the cylinder being fitted on to the slide rest, whereby it may be traversed in the direction of its length, so that the cutter may act on the whole of the internal surface.

We now come to the last of the above tools, figure *e*. This tool consists of a central guide, *h*, on each side of which, at some distance from it, is a sharp cutting edge, shown at *f* and at *g*. This tool is intended for the production of annular grooves, but it also is useful for enlarging holes, and for cutting out rings.

Fig. 53.



We cannot conclude the present section without taking notice of a handy tool for cutting out discs in leather, thin wood, pasteboard, and similar substances.

This tool is of the form shown in fig. 53. It consists of an upright shaft, with a sharp point at the bottom to act as a guide, and a slot in the shaft, in which may be fixed, by means of a set screw, the radial arm, *b*, the virtual length of which can be varied by altering the distance to which it is passed through the slot in the vertical shaft. In a similar slot at the end of the radial arm is fixed a small cutting-edge, as shown in the figure. This tool is applied in a similar manner to common dividers when marking a circle.

We have now afforded all the information which will be required by the amateur to enable him to use the various drills, and his own experience and ingenuity will doubtless in a very short time be sufficient to prevent his finding any difficulty in forming for himself any particular drill he may want.

CHAPTER V.

ON SCREW-CUTTING.

Screws are of two kinds, male and female: also called convex, or external; and concave, or internal.

Several methods for originating screws have been proposed and carried into execution, and from these we shall select such as we consider the most useful and interesting.

As the screw is usually considered a continuous circular wedge, the most evident method of describing it is by cutting a piece of paper into the form of the wedge which corresponds to the required screw, and wrapping it round a cylindrical rod whose diameter is equal to the diameter of the intended screw, measured to the tops of the threads.

The interval between the threads, technically termed the pitch of the screw, will vary with the angle of the wedge, the pitch being greater or less, according as this angle is larger or smaller.

The screw will be right or left-handed, according as the wedge is wrapped round it to the right or left.

Double, triple, and quadruple screws, are those which have two, three, or four distinct threads upon them, such as would be produced by placing two, three, or four strings in contact with each other and wrapping them round a cylinder in a flat band. This method is very convenient for screws which are to have a considerable pitch, but also require to be made of as small a diameter as possible, for by this method a much greater amount of bearing surface is obtained than would occur if very broad threads were used.

The screw may also vary in section, that is, the worm or thread passing round the cylinder may be angular, square, round, &c.

The screw may also vary in diameter, and if wedges of the same angle be wrapped round cylinders of different diameters, the threads on the cylinders of greatest diameter will have the greatest pitch, and the reverse.

The degree of accuracy with which the screw must be cut, will depend entirely on the purpose to which it is intended to be applied.

Binding or attachment screws to be used for connecting the various parts of any object to one another, do not require any particular degree of accuracy in their construction. Regulating screws for guiding the various slides and moving parts of machinery, require a much higher degree of accuracy. Such are

the screws of presses, and of lathes; and among the latter, the leading screw of the screw-cutting lathe requires a very great amount of care in its construction, as it is upon this that the accuracy of all screws cut with the point or parting-tool in the lathe to which it belongs, depend for their accuracy and uniformity of pitch; the other screws of the lathe are not of quite so much importance, but the screw on the nose of the mandril requires more care than the others, as the accuracy of all work, of whatever nature it may be, depends in a very great degree upon the correctness of fit existing between the mandril screw and the female screw attached to the back of the chuck.

The highest degree of excellence within the reach of the machanician, is required for the construction of the various screws used for regulating mathematical and philosophical instruments, especially for the micrometrical screws employed for graduating the right lines and circles on the scales of astronomical and mathematical instruments.

If it is intended to originate a screw by the method already referred to, it will first be necessary to cut out a paper wedge of such an angle as will produce a screw-thread of the required pitch. A cylinder of the material of which the screw is to be made, is then truly turned to the external diameter of the required screw, and round this the paper wedge is coiled, being there fastened by gum or other suitable adhesive material. The line of the thread is now marked with

a knife or thin-edged file, and the groove thus produced is enlarged until the screw-thread is perfected, which may be done either with the file entirely, or with the file assisted by the point-turning tool.

Before the introduction of the screw-cutting lathe, the following method of originating a screw invented by a workman, named Anthony Robinson, was adopted at the Soho works:

The screw was seven feet long, six inches in diameter, and of a square triple thread: after the screw-blank was accurately turned as a cylinder, the paper was cut parallel, so as to exactly meet round the same; it was then removed, and parallel oblique lines were drawn across it in ink, which lines represented the margins of the thread and fixed its position.

The paper was then replaced upon the screw-blank, and the lines were marked through on to the screw-blank with a pointed steel punch, called a centre-punch. The paper was again removed, and the dots connected with one another by fine lines carefully cut with a sharp file; the spaces between the threads were then cut out and rendered sufficiently smooth by means of files to serve as a lead or guide.

The screw thus partly formed was then temporarily suspended in a cast-iron box, and while in that position a quantity of melted lead mixed with tin was poured around it, whereby a guide-nut was formed.

All that now remained to be done, was to attach cutters of a suitable form to the box or guide-nut, but

with an adjustement to regulate the depth of cut, forming, in fact, a species of slide-rest, after which the screw was completed by handing it round with levers.

The following plan for originating a screw has been described by Mr. Mallet of Dublin: Two straight edges of equal depth, and in thickness about five-eighths of an inch, are to be carefully secured upon a table with their edges uppermost, and exactly parallel to each other. Between these a third straight edge is to be secured in a diagonal direction from one to the other; this straight edge is to be made of two thin slips of wood glued together, between which is previously inserted a piece of Bristol board.

The entire height of the diagonal straight edge must be a shade greater than that of the two parallel straight edges.

The edge of the Bristol board is now to be charged with printer's ink, and the screw-blank which has been previously turned to a true cylinder rolled along the two parallel straight edges, during which operation a spiral of very considerable accuracy will be marked upon the screw-blank by the edge of the Bristol board. The line thus obtained may be cut, and the screw completed according to the method described, for the screw marked by coiling a paper wedge around it.

A variable screw, that is to say, a screw whose pitch is not the same throughout, may be obtained

by replacing the diagonal straight edge by a curved slip.

Screws are also originated by indenting a smooth cylinder with a sharp-edged cutter placed across it at the required angle, the surface or rolling contact between the cutting-edge and the cylinder producing the rotation and traverse of the latter.

The following is the most simple application of this method: Let a deep groove be made in a piece of board, in which bury a piece of stout wire at some little distance below the surface, and let the wire be perfectly straight.

A second groove is now to be made across the former to fit the cutter exactly, which is not unlike a common table-knife, and which is placed in this groove at the angle which is required for the generation of the screw. The cutter being slid over the piece of straight wire in dents, it carries it round and traverses it endways in the path of a screw; a helical line is thus obtained, which, with sufficient care, may be perfected into a screw sufficiently good for many purposes. Mr. Henry Maudsley employed a cutter upon cylinders of wood, tin, brass, iron, and other materials, mounted to revolve between centres in a triangular bar-lathe. The knife was hollowed out upon the edge to fit the cylinder, and fixed into a block adapted to slide upon the bar. The cutter being fixed at the proper angle indented the revolving cylinder, and was carried along by the oblique incision thus made.

Some hundreds of screws were thus made, and their agreement with one another was in many instances quite remarkable, and upon the whole Mr. Maudsley gave his preference to this method of originating screws.

Screws are also originated by traversing a cutting tool along a plain revolving cylinder in a right line parallel to the axis of the cylinder.

Sometimes the tool has many points and is guided by the hand alone; at other times the tool has only one single point of a suitable form to produce the required thread, and is guided mechanically, as will be hereinafter explained.

Screw-cutting tools may be classed under two heads: first, those which may be used either with or without the assistance of the lathe; and second, those which can only be used with the lathe.

It is easy to imagine that, when one screw, either solid or hollow, has been produced by any of the foregoing methods, by its means a counterpart may be produced; all that is requisite by way of preparation being to furnish the first screw with a number of cutting-edges to clear out the thread, and this may readily be done by cutting away the thread in the direction of the length of the original screw.

As each screw produces its counterpart, it follows that to prepare the thread of a male screw, a female screw will be required, and to cut a female screw a male screw will be requisite. The male screw, when

properly prepared for cutting counterparts, is called a tap, and the female screw is called a die, or box, and those which are retained for making dies are called master-taps.

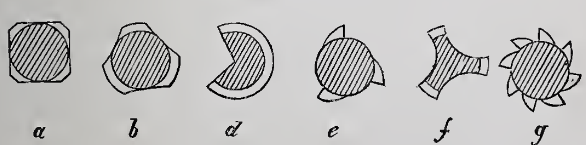
In constructing these taps and dies, care must be taken to cut the grooves so that the cutting-edges are keen, and ample space in allowed for the escape of the matter which is removed by the cutting-edges.

For tapping metal and other hard materials, three taps are requisite; the one which is first applied is very taper, having little or no thread at the point, the remainder being turned off; the second has more of the thread left on, being, in fact, of the full diameter of the screw at the top, but it is also somewhat taper. The third and last tap, which is called a plug-tap, has the full depth of screw-thread all along its length and is perfectly parallel; this is used for clearing and equalising the thread. For soft materials, two and sometimes even one tap will be found sufficient.

The taps are made of various sections, according to the material for which they are intended.

A few of these sections are shown in the subjoined figure.

Fig. 54.



The simplest form of tap may be produced by filing four planes along the whole length of the tap, as showed at *a*, fig. 54; but in this tool the edges are very obtuse, so much so, indeed, that the thread of the screw formed by it is produced rather by burring or pressing than by actual cutting.

This tap, as well as, those represented at *b*, *d*, and *f*, will cut in both directions—that is to say, it cuts while being screwed into the aperture prepared for it, and also while being screwed out.

The shaded parts of the taps represent the solid centre of the screw, and the plain parts represent the thread of the screw.

A better form of tap is obtained by only filing three planes on the screw instead of four, and for very small taps this is usually done, as it is difficult to obtain a good sectioned tap of very small diameter, though this may, by great care and the use of a very keen triangular file, and also a mouse-tail file or small half round, be produced. The section of tap produced by filing three planes upon it is shown at *b*. Even in the last-named tap the angle of the cutting edge is as much as 120 deg.

For general purposes the best angle for the cutting-edges of taps and dies is 90 deg., which is that produced between the circumference of the tap and a radial line.

Mr. Holtzapffel remarks, that when two-thirds of the circle are allowed to remain, as shown at *d*,

instead of only half, as at *c*, although the tap is somewhat less penetrative than the last, it is also much less liable to displacement with the tap-wrench.

It is much more usual to employ three radial cutting-edges instead of one only, as the best form of tap is only required to cut in one direction, or only during the time that it is being screwed into the nut or aperture which is to be screwed; the remaining edges are then chamfered or bevilled off, in order to allow of the escape of the turnings. By this method a tap is produced which is in section somewhat similar to a ratchet-wheel, having, three four, or more teeth, as shown at *e* and *g*.

e represents a tap for cutting a left-handed screw, and *g* shows the section of a tap intended to produce right-handed screws; both cut the same way.

If we closely examine all these sections with regard to their general suitableness to the requirements of the practical man, we shall find that they all of them are liable to more or less serious objections, and it is on this account that the section of tap shown at *f* is most generally adopted in practice for the common working-taps; and this form may be said to combine nearly all the advantages of every other section, with few or none of their disadvantages.

These taps may have the concave grooves along their sides cut either by means of a round file, or

by a tool whose edge is of the proper form, and which may be used with either a planing or shaping machine, or even with the lathe.

The master-taps are usually better made than the working-taps, and have the grooves which are cut longitudinally upon them of a rectangular section, by which a certain object is intended to be gained, which will be referred to in a subsequent part of the present chapter.

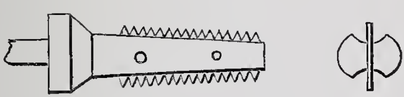
All these taps may be hardened in the manner employed for the application of that process to the various cutting-tools.

Before taking leave of the taps for the present, we consider it desirable to describe a tap invented by Mr. Siebe, which is worthy of some attention from the wood-turner. The great peculiarity of this tool is, that the same tap may be used for cutting both right and left-handed screws. The tap is thus formed: A piece of hard wood of a suitable form and size having been selected, is turned down to a true cylinder, whose diameter is equal to the greatest diameter of the proposed tap; a thread of the proper depth and thickness is then turned upon it.

A longitudinal slit is now cut through the whole length of the screw, and into this slit a thin plate of steel is inserted of the length and breadth of the required tap. The edges of this plate are now cut into notches corresponding with the thread of the screw. The steel plate is now removed, and the thread turned

off the wooden cylinder, leaving a plain cylinder. The steel plate is again inserted into the slit in this cylinder and there securely fixed; it is made to taper slightly on the edges, in order that its cutting action may be gradual. A groove cut on each side of the steel plate affords egress to the shaving produced by the action of the plate. The upper end of this cylinder is cut square, to admit the tap-wrench to be fitted on. A right or left-handed screw is produced by turning the tap to the right or left. Such a tap as this may also be made by filing notches in the edge of the plate without the assistance of the wooden worm, but care must be taken that a tooth on one edge of the plate is opposite an opening on the other edge. An elevation and section of this tap are shown in the accompanying fig. 55.

Fig. 55.



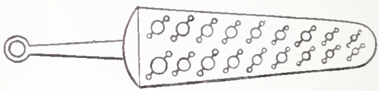
Mr. Siebe has also proposed taps similar to the above, with only two cutting-edges, for cutting screws in metal.

Having thus fully considered the form and principles of such taps as are suitable to the various kinds of nuts and hollow screws which may be required to complete the works of the turner, we

shall proceed to the description of the various dies, die-stocks, and screw-plates, which are used for the production of solid screws.

These dies may be conveniently cut by means of the master-taps.

Fig. 56.



For solid screws whose diameter is not more than one-eighth of an inch, the apparatus represented in fig. 56 will be found convenient, and it is frequently used for screws of much larger diameter, although the work produced by it is by no means equal to that produced by dies which are made in two parts. The above instrument, which is called a screw-plate, is of very simple construction, easily made, and easily used.

To obtain a screw-plate of the above description for screws of any diameter, the operator must first provide himself with a good tap of the required dimensions. The next point to be considered is the selection of suitable materials for the screw-plate.

For a small screw-plate it will be found very convenient to use an old file, which must first be softened by carefully raising it to a low red heat, and allowing it to cool gradually. This being done, the

teeth must be carefully removed by the grindstone, so as to leave the plate perfectly smooth.

The requisite number of holes are now accurately drilled and broached out, some parallel and some taper, making two or three for screws of each diameter.

The slots cut down the sides of the holes to produce cutting-edges and afford egress to the chips are now cut out with a fine file of suitable dimensions, after which the various apertures are screwed by means of the taps mentioned above.

Such part of the threads and cutting-edges as may have been burred in the operation of tapping are now cleaned out with a fine file, and a plug-tap passed trough the hole to clear the thread, when the screw-plate will be ready for hardening.

This is a process which requires a considerable amount of care in order to obtain a satisfactory result.

The plate should now be carefully raised to a red heat an plunged edgeways and horizontally into a trough of salt-water, and allowed to remain there until it becomes cool. By these means the plate will be rendered very hard, and also very brittle. In order to prevent the danger of breakage from the brittleness thus imparted to the screw-plate, it must be tempered by being heated over a clear fire, or in a bath of fusible metal, until a pale straw-yellow colour appears upon its surface, when it is set aside to cool.

The screw-plate thus produced may now, if the

manipulator desires, be polished, when it will be complete and ready for use.

We will now explain the construction of the ordinary dies, which are more satisfactory than the screw-plate thus described, as these dies admit of being sharpened, which the cutting-edges in the screw-plate do not.

FIG. 57.

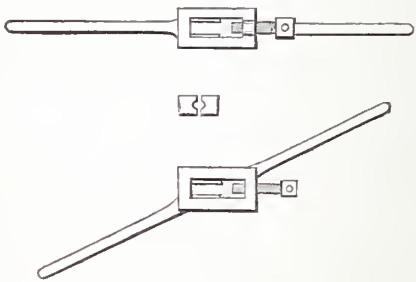


Fig. 57 represents two forms of die-stocks, in which to retain the dies while in use, and also a pair of dies.

The dies are usually made in two pieces, as shown, and are furnished with a v groove on the sides, as shown by the dotted lines, which groove fits upon a corresponding ridge in the die-stock.

The dies may be made as follows: A piece of good steel of a suitable thickness having been selected, and carefully softened according to the method hereinbefore described, it is accurately drilled or bored to a diameter a shade less than the diameter of the screw

to be produced by it, this diameter being measured at the bottom of the groove between the threads.

For the production of solid screws, one pair of dies will be found sufficient, as the distance of the dies apart can be regulated by a set-screw.

The dies should be provided with cutting-edges on the line of division, and also at two other places; the former edges will then admit of being sharpened by. rubbing on an oilstone.

The dics when completed for hardening are divided usually into two pieces, although it is much better to have them in three segments, on account of their requiring less complicated stocks.

The stock consists of a socket to contain the dies, furnished with two handles and a set-screw, or the set-screw may be made upon the end of one of the handles. The socket is furnished with v ridges, or feathers, as above stated, and shown in the figure; but these feathers are not continued through the entire length of the socket, a portion being cut away to allow of the insertion and removal of the dies. This apparatus is thus used: The rod upon which it is required to cut a screw is firmly fixed in the vice. The dies are separated to some distance from each other in the die-stock, then placed on the rod and screwed up tolerably tight, and, oil having been supplied, the first cut is made by working the dies round by the handles of the stock until it moves freely the whole length of the required

screw, when it is screwed up tight again, and the process repeated until the perfect screw is produced. This may also be accomplished by placing the screw between the lathe centres, and causing it to revolve while the dies are screwed down upon it, the die-stock being prevented from revolving by resting one of its handles on the lathe-bed.

Dies very similar to the above are also used in a machine called a screwing-engine, which somewhat resembles a lathe with two slide-rests and a reversing motion.

Those dies which we have now described are intended for metal and other hard material. It may be thought at first that we have given to much space to the consideration of these tools for working metal, but it will appear, upon a due consideration of the merits of the case, that the present chapter is one of the most important in this treatise, as screws will be required by the amateur turner for a very great variety of purposes; and, wherever they are used, the accuracy and durability of the machine whose parts they hold together depend, in a great measure, upon the accuracy of those elements.

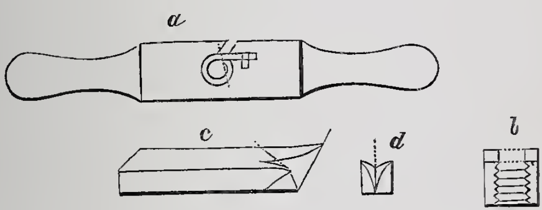
Let us suppose, for instance, that the amateur is desirous of making some scientfic apparatus. In this case, the firmness of the whole machine, its accuracy of construction, and the means of its adjustment, will generally be found to depend almost entirely upon the accurate fitting of the various screws em-

ployed both for holding its parts together, and for adjusting it when in use.

The dies used for cutting screws in soft materials, as wood, &c., although indentical in principle with the foregoing, are somewhat different in construction, and to these we will now turn our attention.

The apparatus used for cutting screws in wood consists of a female screw, or screw-box, as it is called, in which a steel cutter is fixed.

Fig. 58.



The screw-box is represented in the accompanying figure. *a* is a plan, and *b* a section of the entire apparatus.

It consists of two pieces of wood accurately attached together by two screws, and rendered still more steady by two pins, so arranged as to admit of the separation and readjustment of the two pieces. The ends of the thickest part are usually made into handles, by which the instrument is worked. A perforation is made through the two pieces of wood; the hole in the thinner piece is bored cylin-

drical, and exactly agrees with the external diameter of the screw, or of the prepared cylinder. The hole in the thicker piece is screwed with the tap which is used for preparing the internal screws and nuts which correspond to the solid screw to be produced. The cutter for producing v threads, which is fitted into the box, has a thin cutting-edge, sloped externally to the angle of the thread, usually at about 60 deg., and thinned internally by a notch made with a triangular file. The cutter is inlaid in the thicker piece of wood, and fastened by a hook-formed screw-bolt and nut. In placing the cutter, great attention must be paid to the conditions requisite to obtain such an arrangement as will allow the cutting-edges to come into action at a suitable angle.

The angular ridge of the cutter should lay as a tangent to the inner circle, and its edge should be sharpened by grinding on the plane indicated by the dotted line, or at an angle of about 100 deg. with the back.

The point of the cutter should exactly intersect the ridge of the thread, and it should lie at precisely the rake or angle of the thread, for which purpose it is inlaid deeper at its blunt extremity.

The piece of wood of which it is intended to construct the screw should be turned cylindrical, and slightly taper at one end. It is then twisted into the screw-box, when the cutter makes a notch in it which catches upon the wooden thread immediately

behind the cutter, and it is thereby carried forward at exactly the rate of the screw thread.

The whole of the material is thus removed at one cut, the shavings making their escape at an aperture or mouth made in the side of the box for that purpose.

The cutter is shown at *c* and *d*, the former being a side elevation, and the latter a front elevation.

Screws of half an inch in diameter and upwards are fixed in the vice, and the screw-box handed round like a die-stock; but for large screws, exceeding two or three inches in diameter, two of the v's, or cutters, are fixed in the box, so as to divide the work and lessen the risk of breaking the keen edge of the cutter.

The screw-box may be used for screws of four, six, and eight inches in diameter, but these large screws are seldom made now in wood, metal screws having taken their place.

For producing nuts or hollow screws in wood, taps similar to those already described for similar works in metal may be used.

Having thus carefully described the various forms of taps and dies both for wood and metal, we shall now give some description of the screw-cutting lathe, and of the manner of working it, for the instruction of those who may feel inclined to construct machines with screws for working or adjusting them; and in treating of these we shall also include the cutting

of screws in the common lathe, by means of many pointed tools, termed screw-tools.

The screw-cutting lathe has many advantages besides that which its name indicates; for instance, the motion imparted to a slide-rest by a leading-screw is far more steady than that which is obtained from spur gear.

The screw-cutting lathe is also required for turning spirals, such as are used for the legs of small side-tables, fire-screens, &c.

The principle of the screw-cutting lathe, or engine, is as follows: Suppose a cylindrical rod to be caused to revolve at a certain definite speed, and let a cutting-tool be applied to it, which tool is attached to a nut moving on a screw parallel to the above cylinder; then if the screw makes one revolution whilst the cylinder makes one revolution, it is evident that a screw will be cut upon the cylinder, whose pitch is exactly equal to that of the leading-screw. If the cylinder is caused to revolve in the same direction as the leading-screw, and the leading-screw is right-handed, the screw cut upon the cylinder will be right-handed; but if they revolve in opposite directions, it will be left-handed.

The ratio of the velocity of the cylinder upon which the screw is to be cut to that of the leading-screw may, by using wheels properly proportioned, be made to assume any required value; therefore, if the pitch of the leading-screw be known, a screw

of any required pitch may be obtained, and, as we have seen above, the screw may be made either right or left-handed.

It is desirable in this part of our subject to consider the means by which the pitch of the intended screw is to be regulated, but those who object to the inconvenience of calculating the diameters of the change-wheels as they are called, can avoid it by the use of tables.

We must first observe that, as the pitch of any screw is simply the distance from the centre of one thread of the screw to the centre of the next, it is evident that the diameters of the screws do not enter into the calculation, therefore we only have to consider the ratio of the pitches of the leading and required screws.

Suppose we require a screw of twice the pitch of the leading-screw, then the latter must make two revolutions while the lathe-mandril makes one; to effect this, we must have a spur-wheel on the shaft of the leading-screw, whose diameter is half that of a spur-wheel on the lathe mandril, and these wheels are put in communication by a proper number of intermediate wheels which gear with them and with each other; thus if the leading-screw is right-handed, and a right-handed screw is required, one wheel is used to connect that on the lathe-mandril with the wheel on the shaft of the leading-screw; but if a

left-handed screw is required, it may be obtained by using two intermediate wheels.

Fig. 59.

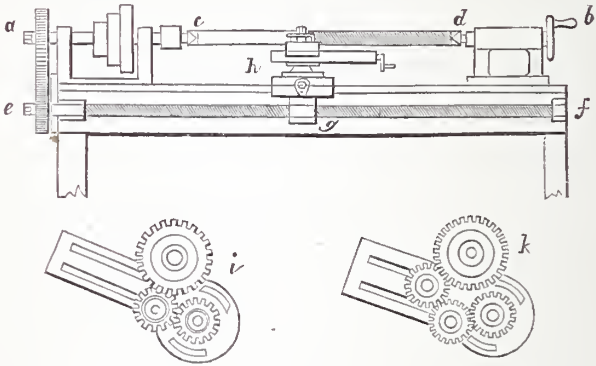


Fig. 59 represents a small screw-cutting lathe of the usual construction.

The lathe is similar to the ordinary foot-lathe in its general form, but the mandril is carried in a bearing or collar at the back, and prolonged backwards, being turned cylindrical at a short distance behind the poppet-head, and fitted with a fixed key or feather to cause any spur-wheel which may be placed upon it to revolve with the mandril; beyond this cylindrical part a short screw is cut, fitted with a nut, by which the spur-wheel is retained on the shaft.

The wheels are so bored as to slide freely on to, or off from, the end of the lathe-mandril; they must

also have their teeth of the same pitch for all the wheels, so that the number of the teeth on any wheel may be exactly proportional to the diameter of the wheel.

The end of the leading-screw is similary formed to that of the mandril, for the same reasons.

The intermediate wheels are carried upon adjustable studs, which may be fixed in any required position according to the diameters of the wheels. Supposing the leading-screw to be right-handed, we have shown the arrangement of wheels for cutting a right-handed screw at *i*, and *k* represents the train of wheels requisite to produce a left-handed screw, but if the change-wheels in this latter case happen to be of such diameters that they will gear into each other direct, the intermediates may, of course, be dispensed with.

We may here give a general rule for finding the diameters of the change-wheels, requisite to produce a screw of any required pitch.

As the pitch of the required screw is to the pitch of the leading-screw, so is the diameter of the mandril-wheel to the diameter of the leading-screw wheel; or, in other words, if you have decided upon a wheel for the mandril, then to find the diameter of the leading-screw wheel we proceed as follows: Multiply the pitch of the leading-screw, by the diameter of the mandril-wheel, and divide the product by the pitch of the the required screw, the quotient will

be the diameter of the leading-screw wheel.

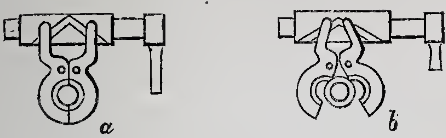
Care must be taken to select a wheel for the mandril, which will not be sufficiently large to interfere with that on the leading-screw, otherwise the calculations will have to be performed again, and it may be some guide to remember, that if the required screw has the greater pitch, the wheel on the mandril will be of larger diameter than that on the leading-screw, and if the pitch of the required screw is less than that of the leading-screw, the mandril-wheel will be smaller than the leading-screw wheel.

The change-wheels should be carefully constructed, the teeth being properly shaped, so that the motion may be smooth and free from jerks when any two of them are in gear. The change-wheels having been properly arranged, we must now consider the other parts of the screw-cutting lathe. The poppet heads are, in all respects, except the bearing of the mandril, the same as those represented and described under fig. 13, p. 27.

The lathe-bed, with its supports, fly-wheels, &c., is similar to that described at the commencement of the work, and represented at fig. 1, p. 17.

The slide-rest has all the details of the slide-rest shown at fig. 12, p. 26, with one additional piece to connect it with the leading-screw; hence, all that remains to be described is the leading-screw, and the means by which it is geared with the slide-rest.

Fig. 60.



The leading-screw should be carefully turned, of such pitch that it will work smoothly at any speed: it is connected with the slide-rest by a split-nut, which allows of being opened and closed.

This split-nut is represented in fig. 60. *a* shows it in gear with the leading-screw, and *b* represents its position when out of gear; each half of the nut works upon a small pin or axle, beyond which it is continued in the form of a fork. The two prongs on each half-nut gear into a short screw right and left-handed, as shown, and of great pitch; this screw is turned round by a short handle, and a small part of a revolution is sufficient to throw the slide-rest into, or out of, gear with the leading-screw.

Other arrangements are sometimes adopted to effect the same ends, but they are so similar that the above description will suffice for most of them.

Tools of various forms are used for cutting screws in this lathe, according to the form of thread to be cut; they, all of them, have one point only.

When a square-threaded screw is required, a parting-tool will answer the purpose; if it is to be a v-

thread, a point-tool must be used; but if a thread whose section is curved be required, a tool should be made whose edge is a counterpart to that section.

We will now describe those tools which are used for cutting fine thread screws in the common lathe.

These tools, called screw-tools, are used for both solid and hollow screws, and are, in fact, very short segments of screws. They are represented in the subjoined sketch.

Fig. 61.

At *a*, fig. 61, is shown a screw-tool, intended for cutting external screws, and at *b* one for producing internal screws; this latter bearing the same relation to the former that the side-tool bears to the chisel.

The screw-tools may be made by holding a piece of soft steel against a master-tap, whilst the latter is revolving in the lathe; but care must be taken to obtain a complete section of the thread at the corner, *c*, of the tool, which edge makes the first indentation upon the cylinder from which any required screw is to be made.

The tool, having been thus cut, is hardened and tempered, and sharpened by grinding it upon the top surface.

The amateur will find it very convenient to be able to make his own screw-tools, as beginners frequently break these delicate instruments, and if fresh tools

have to be purchased after every such accident, the delay occasioned thereby will be very great.

The action of these tools is as follows: The cylinder of which the required screw is to be made being fixed in the lathe, and caused to revolve at a suitable speed, the screw-tool is pressed against it; the various cutting-points make so many grooves upon the surface of the cylinder into which the threads following the cutting-edges fall, and by which the screw-tool is carried forward at exactly the speed or pitch of the tap from which the screw-tool was made.

When the tool has reached the end of the intended screw, it is removed from the work, and again replaced at the commencement of the thread, and this operation is repeated until the screw is cut to a proper depth.

In cutting screws which terminate with a collar, some dexterity is required to remove the tool the instant it arrives at the bottom of the collar, in order to prevent a collision, which would either spoil the screw or break the screw-tool, or perhaps effect both, and this difficulty will necessarily increase with the speed of the screw which is being turned.

We have now described all the tools used for screw-cutting, which will be required for the purposes of the amateur, and we will now show the methods by which these tools are applied to the work for which they are designed.

For this end, we think that we cannot select a

more convenient method of explanation than that of taking several examples of different forms of screws, and giving full instructions for cutting them. We shall therefore adopt this method.

In the first place, let it be required to turn a small screw and nut of about one-sixteenth of an inch in diameter. Then, having selected a piece of iron, steel, or other wire of the required size, let it be firmly fixed by one end in the vice, and let the other end be slightly tapered off so as to enter the screw-plate readily. It may then be removed and placed in a small hand vice, which is held in the right hand, and the screw-plate being taken in the left hand, the wire is to be twisted into the taper hole. By these means the thread will be partially cut; the wire is then unscrewed from the plate, and twisted into a parallel hole, whereby the thread is rendered perfect.

In this operation, as well as all similar ones where metal is the material operated upon, it should be kept well supplied with oil to prevent the work and screw-plate from becoming hot by friction.

When the screws are larger than the above, they may remain in the vice while being screwed, the screw-plate being turned by means of the short handle with which it is usually furnished.

It now remains to form the nut corresponding to the above screw.

A piece of plate metal is selected, drilled, and, if

it is to be very accurate, faced and turned on the arbor-chuck; the faces or sides are filed upon it, and the blank thus produced is fastened in the vice. If the vice is of iron, with teeth, it should be furnished with lead clamps over the jaws to prevent the teeth from injuring the sides of the nut.

The nut being fixed, it is now tapped by twisting a small taper tap into it; after which a parallel or plug-tap is also used.

These taps are made of steel wire, usually flat on the sides, for such small nuts, and turned by a handle formed by bending the end of a wire into a ring. If a larger screw is required, such as the thread by which the lid of an ivory needle-case is retained on the case, we must have recourse either to the dies and stock, or to the lathe and screw-tools.

The latter will be preferable for this purpose, but for many similar ones the dies will suffice. We will therefore first suppose such to be the case.

A piece of the material from which the screw is to be made having been turned down to a cylinder of the proper diameter, and perfectly parallel, it is fixed in a vice, the same precautions being taken to prevent injury as before stated.

The proper dies are now selected and placed in the die-stock, which being passed over the end of the cylinder, the dies are pressed together by the set-screw, until they take a firm hold of the material to be screwed. The first cut is then made, turning the

die-stock round until it has descended the entire length of the screw, the dies are then tightened up and the cut made deeper, and this process is continually repeated until the screw is perfected.

We find that by having these adjustable dies we may avoid the necessity of having both taper and parallel dies.

The threads should not be sharp v-shaped threads, but they should be somewhat round at the top and bottom, as they are otherwise somewhat liable to injury.

These dies act partly by cutting and partly by squeezing the material into form, which will be rendered evident by an inspection of the thread after the first or second cut, when it will be found to have assumed a very rough, uneven surface, formed by two narrow ridges, including a groove between them.

The nuts for these large screws are similarly made to those for the small ones, but three taps will be necessary: one for the first cut, very taper, with no thread on the point, and only half the whole depth of thread on the thickest part; the second also taper for the second cut, with the diameter of the thread commencing where that of the first ended, and being of the full diameter at the upper end of the tap.

The third tap is parallel, or a plug-tap, and is used after the other two for clearing the thread out to a uniform size.

These taps require a greater amount of force to twist them into the nuts than could be applied through

the medium of a small handle. It is therefore necessary to have recourse to a lever which is called a tap wrench, and is furnished with a small square block, in which a square hole or slot is made, which fits a corresponding projection on the top of the tap.

Taps are also made to use with a screwing machine, but they are larger than hand-taps.

Taps are also used for clearing out worm-wheels, or wheels for working in gear with a tangent screw; the edge of the wheel forms a segment of a continuous nut, in which the short threads are first produced by a single-pointed cutter acting at the proper angle to the axis of the wheel; and they are then cleared out by being worked in gear with a hob, or kind of master-tap, usually made of wrought-iron, and case hardened.

The screw-box for producing wood screws is used in a very similar manner to the dies already described. The cylinder upon which a thread is to be cut is fixed in a vice, the end of it is then passed into the aperture of the thinnest part of the screw-box, the box is then turned round while a slight downward pressure is applied to it, which causes the cutter to bite; this being accomplished, no further pressure will be found necessary, as the wooden thread in the box will gear into the groove produced by the cutter upon the cylinder, whereby the box will be carried forward at exactly the rate as the thread of the intended screw. This screw-

box is only suited to soft materials—such as soft wood, &c.

The taps used for wood are similar to those already described, but as a rule they should be made with more acute edges than those used for metal and other hard materials.

We now come to the consideration of the manipulations when the many-pointed screw-tools are employed.

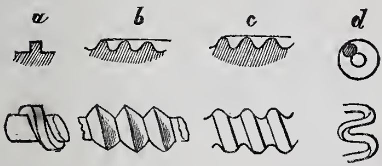
These tools are applicable to various diameters of screws, but as the thread will always make the same angle with the axis of the screw whatever may be the diameter, hence the greater the diameter of the screw the greater will be its pitch; or, in other words, with the same screw-tool the pitch of the screw will, in every case, bear a certain fixed proportion to its diameter. Let it be required to turn an ivory match box with a top to screw on, and let us suppose that the box is reduced to a fit condition for the screw to be turned upon it.

The box may now be fixed in any convenient way in the lathe, and this being set in motion, a screw-tool whose threads run at the proper angle is applied to it; when the screw is finished, a shoulder is turned upon the box where the screw terminates.

The internal screw may now be cut in the top of the box, and the edge of the box faced. The top may now be screwed on to the box and finished.

When large screws are required, or screws of a particular pitch for which the dies which the operator may possess are not suitable, recourse must be had to the screw-cutting lathe.

Fig. 62.



The first matter which occurs for our consideration is the form to be given to the screw-tool.

In the accompanying fig. 62 we have shown a few varieties of screw threads.

a represents a square-threaded screw, which is the strongest section that can be adopted. The most suitable tool for producing this thread, is a parting-tool whose thickness is somewhat less than half the pitch of the required screw. If the screw is to have a very sharp pitch, the part of the parting-tool below the cutting-edge must be sloped at a suitable angle to the axis of the screw, or the depth must be very inconsiderable, otherwise the bottom of the parting-tool will rub against the sides of the thread and cause the tool to shake or chatter, as it is called, whereby a very uneven surface will be imparted to the sides of the thread, which will

interfere materially with the smooth working of the screw.

If it is desired to produce a highly polished surface upon the screw, it may be produced by applying crocus or putty powder to the screw by means of a soft metal lap of suitable form, made by casting a nut upon the screw when it is turned. The metal should be in the proportion of one part by weight of antimony, with nine and a half parts by weight of lead.

The next section, *b*, represents what is called the v threaded screw. The threads should not be quite angular, but rounded at the top and bottom, otherwise the keen edge would be very liable to be injured.

The screw may be conveniently cut with a point-tool.

The next screw, *c*, has a semi-circular thread, and requires a special form of tool for its production.

The last sketch in our figure, *d*, represents one form of spiral.

Spirals may be divided into two sorts: the first class may be considered as the threads of screws, from which the centres have been removed; and the second class may be regarded as screws of which the thickness of the thread is equal to the external radius of the screw.

The various tools which may be required by different forms of threads, should be filed into form

while the steel is yet soft, and should only be sharpened by grinding upon the top surface.

Fig. 63.

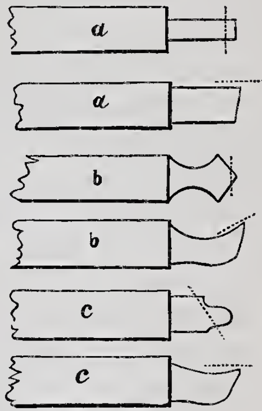


Fig. 63 represents the various tools used for producing those threads which we have already described.

a a show a plan and elevation of the tool used for square-threaded screws; it is similar to the common parting-tool.

b b show a plan and elevation of a point-tool suitable for forming the threads of the v-threaded screw, and also for commencing the threads of screws of more complicated section, which are afterwards completed by other tools.

c c are similar representations of the tool used for finishing the screws with semi-circular threads.

The dotted lines show the surfaces upon which the tools should be ground.

We will now give instructions for the formation of various screws by means of the screw-cutting lathe.

The first process is the calculation of the diameters of the change-wheels, which will necessarily be the same whatever form the thread of the screw may have.

We will suppose the distance from the centre of the lathe-mandril to that of the leading-screw to be eight inches, and the pitch of the leading-screw we will take as a quarter of an inch, the pitch of the intended screw being seven-sixteenths of an inch. The pitch of the proposed screw being greater than that of the leading-screw, it follows that the wheel on the lathe-mandril will be larger than that on the leading-screw.

To make sure of the wheels clearing each other, we will fix a wheel of eight inches in diameter upon the mandril, then as the periphery of this wheel will only reach over four inches, or half the distance between the mandril-centre and the centre of the leading-screw, and the wheel upon the latter being smaller will not reach so far, it follows that these will clear each other well. Applying the rule given above, we have

$$\frac{8 \text{ inches} \times {}^{1}/_{4} \text{ inch}}{{}^{7}/_{16} \text{ inch}} = 4\,{}^{9}/_{16} \text{ inches}$$

nearly.

If the operator is not possessed of wheels of these dimensions, he may substitute for them, being careful, however, to keep the ratio of 128 to 78 between the diameters or number of teeth on the wheel.

The requisite wheels being fixed upon the shafts as above, a number of intermediate wheels, according to the direction of the required screw, are

fixed and adjusted upon the studs fitted to the lathe for that purpose.

The cylinder upon which the screw is to be cut may then be fixed between the centres, and the cutting-tool, having been properly ground and set upon an oil-stone, is to be firmly fixed in the slide-rest at right angles to the axis of the intended screw; it is retained in its place by a pair of clamping pieces screwed down upon it by nuts working upon screwed studs fixed to the top table of the slide-rest.

If the material of which the screw is to be made is wrought-iron or steel, a solution of soft soap in water which has been previously prepared, should be allowed to drip upon the point of the tool during the whole time that it is in action.

The lathe being arranged and adjusted as above, it may now be set in motion, the speed depending upon the nature of the material used, if the screw is right-handed, the slide-rest is now slid to the end of the cylinder to be cut which is farthest from the front poppet-head, but if it is intended for a left-handed screw, the slide-rest is placed at the end nearest the front poppet, and when placed in one of these positions, the first cut is commenced by advancing the tool through a certain space equivalent to the depth of the first cut, and at the same instant putting the slide-rest into gear with the leading-screw; this may, however, be done before starting the lathe, if the operator prefers this method.

It will sometimes be found desirable to mark the commencement and end of the grove between the threads by drilling a hole whose diameter is equal to the width of the groove, and its depth equal to the depth of the groove. As soon as the tool arrives at the end of the thread, it is withdrawn by working the screw attached to the top slide, and the rest is thrown out of gear with the leading-screw and slid back to former position, and the second cut taken.

This operation is repeated until only the finishing cut remains to be made, and before doing this the screw must be examined to see that there are no serious irregularities in any of its surfaces.

If the screw is accurate, we may now proceed to take the finishing cut, which is usually done with a tool having a much keener and more carefully got up edge than those previously used.

If a screw with a semi-circular thread is to be cut, it may be commenced with a point-tool, and afterward completed by a tool of the suitable form.

To turn a spiral, more care is required than that necessary for the production of a common screw. It may be done principally by the point-tool, but it may be finished by means of tools with variously-formed edges, and it will be greatly improved by smoothing and polishing.

Spirals are usually made only in ornamental woods, being generally employed for legs to side-tables, and for ornamental purposes.

We have now completed our account of screw-cutting generally, so far as regards the production of the thread; the various minor details, such as the formation of milled and capstan heads to screws, will receive our attention in a subsequent chapter.

CHAPTER VI.

ON MISCELLANEOUS APPARATUS AND MANIPULATIONS.

Having now described and explained all the most important processes with which the turner will find it necessary to be acquainted, we deem it desirable to consider sundry miscellaneous processes which could not be properly included in any of the foregoing chapters.

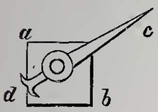
In the present section, then, we purpose to treat of the many little means which must be taken to ensure success or add to the ease of construction.

In the first place, we shall turn our attention to the means of recovering the position of a lost centre, which is necessary in such cases as the re-turning of various objects.

We shall first explain the methods which are usually adopted by those who are accustomed to the practice of turning.

The instrument which we are now about to describe in called a scribing block; it is represented in the accompanying fig. 64.

Fig. 64.



a b is a block of hard wood, to which the scriber, *c d*, is attached. The apparatus is thus used: The cylinder of which it is required to find the centre is placed upon temporary bearings, and, the scribing-block being placed near it, the scriber is turned round upon the pin by which it is attached to the block, until the point of it is upon a level with the centre of the cylinder, as near as may be judged; a mark is made with the point of the scriber upon the end of the cylinder; the cylinder is then turned round through a quarter of a revolution, and another mark made; two other marks are also made, each after turning the cylinder through a quarter of a revolution.

By the above process we obtain on the end of the cylinder a square so small that the actual position of the centre may be immediately determined, when it can at once be marked by the centre punch, and subsequently drilled to receive the lathe-centre. This method is, however, not more generally used than one we are now about to describe.

By these means, also, a square is produced about the point which shows the position of the centre of the cylinder.

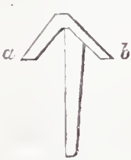
FIG. 65.

The marks are made by a pair of callipers, as shown in the accompanying figure, the callipers being moved a quarter round the cylinder before making each mark.

This method is evidently not so satisfactory, as far as regards accuracy of result, as the foregoing; as the placing of the outer leg of the callipers either a little higher or a little lower at one time than at another, the centre of the cylinder will not be in the centre of the square thus marked upon it.

We are now about to describe a method of finding the centre of a cylinder which, although not in general use, is a far more accurate and expeditious one than either of those above mentioned.

FIG. 66.



The annexed figure is a representation of the instrument with which the process of which we speak is accomplished. It consists of a bevel, *a b*, the edges of which contain an obtuse angle; this angle is bisected by the straight edge of the rule attached to it, which rule is attached to it by means of a long stud, or otherwise the bevel is made very thick.

The following is its principle of application: It is evident, if we cause the two sides of the bevel to rest as tangents to a circle, the angle contained by them being bisected by the straight edge, the latter will necessarily pass through the centre of the circle;

let, therefore, a line be drawn with a scribing-point across the end of the cylinder and close up to the straight edge, then let the bevel be shifted a quarter round the cylinder, and another line drawn in similar manner; then will the intersection of these lines be the centre of the circle, and therefore if the cylinder be true, a point through which its axis passes is therefore a proper place for the countersink by which the work is to be suspended in the lathe-centre.

If the surface of the cylinder should be somewhat irregular, a number of lines should be drawn as above directed, and the mean of the intersections of these lines may be taken as the centre of the circle. If the object of which it is desired to find, the position of the axial line, be a square-headed bolt or other similar article, it is evident that a different mode of construction must be adopted.

This instrument might be formed so as to be applicable to every form of cylinder, by fitting the straight edge on to a triangular stalk or bar of uniform section, which bar may pass through, and accurately fit, a hole in the bevel-stock, at a sufficient distance from the corner of the bevel to clear all probable obstructions.

Fig. 67.

A very useful form of instrument, the object of which is to obtain the diameter of circles, is represented in the annexed figure. It consists of two bars, one of which,

a, is graduated, and slides within the other as shown; the other, *b*, is a plain tubular bar; both of them carry short straight edges, fixed at right angles to the length of the graduated bar.

The instrument is used in the following manner: The two short straight edges are separated from each other, and the edge of the bar, *a*, applied to the surface of the cylinder of which the measure is required. The two straight edges are then brought together and adjusted, so that both they and the graduated bar are in accurate contact with the cylinder, the diameter of which may then be read off from the graduated bar. This instrument evidently measures the cord of an arc of a circle of any diameter, the versine of the arc being the same for every circle, and from this measurement the diameter of the circle is calculated and marked upon the bar, *a*. We have given this explanation of the principle of this instrument that the amateur may be enabled to prepare one for his own use, as they are not generally constructed by the manufacturers of such apparatus.

Fig. 68.

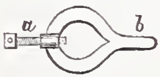


Fig. 68 represents a small but useful apparatus with which the turner cannot dispense. It is called a carrier, and its use is to supply the means of giving the chuck a hold on the work, when the latter is of such a nature that the fork-chuck cannot penetrate it, nor the cup-chuck maintain it in a state of rotation.

The end of the work is then inserted through the aperture in the body, *b*, of the carrier, and firmly grasped therein by the set-screw, *a*.

When the material is of a soft or yielding character a piece of sheet-tin or copper, or stout mill-board, should be first wrapped round it, to prevent its receiving any injury from the carrier.

The work being fixed between the lathe-centres, a pin is inserted into an aperture in the face-plate, or a piece of bent iron into an aperture in the side of a cylindrical chuck, and the end of such pin or piece of bent iron pressing against the tail of the carrier causes the work to revolve with the lathe-mandril.

We may here describe the species of cup-chuck which is also useful when very hard or tough materials, unsuited by their rough character to be used with the cup-chucks hereinbefore described, are to be dealt with.

This chuck is made usually of cast-iron or brass; it is fitted to the mandril in the same manner as the other chucks; it is of the same form as the wooden cup-chucks, but has in its periphery four, six, or eight holes, drilled or tapped, and into these holes are fitted an equal number of set-screws, between which set-screws the work to be operated upon may be firmly held and adjusted.

In using this tool with any soft material, similar precautions may be taken to render the latter safe

from injury, as were recommended in the use of the carrier.

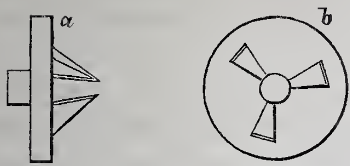
We will now proceed to the description of another kind of chuck, which in some measure answers the purpose both of the inside cup-chuck and also of the arbor-chuck.

This chuck consists of a face-plate accurately turned, in which four radial slots are cut, and within these slots slide four nuts, whose positions are determined and maintained by four accurate screws with square heads, which appear at the periphery of the face-plate; to the four nuts are attached four plates turned up at the end nearest the centre of the chuck, the inner and outer surfaccs of these ends being turned concentric with the lathe-mandril, and being cut in grooves. These plates are called dogs, and the whole apparatus is called a dog-chuck.

If it is required to chuck any article which is to be bored, it is to be placed in the centre of the chuck, and the four dogs screwed down upon it, their position being altered and adjusted until the work is concentric with the lathe-mandril. If any hollow object which is to be turned on the outside, the dogs are brought close together, so as to be placed within the work, when they may be drawn up to their proper position by the screws.

There is another chuck somewhat similar in principle to the foregoing, but it is intended only for solid work. It is represented in the subjoined sketch.

Fig. 69.



In fig. 69, *a* represents a side, and *b* a front elevation of the chuck of which we speak. It consists of a small gun-metal face-plate fitted to the lathe-mandril in the general manner. Upon its face are fitted three jaws or dogs, which by means of screws may be propelled forward or together, or drawn backwards and asunder. This chuck was designed for the use of the chronometer manufacturer, and it is the invention of an ingenious member of that profession.

This instrument is evidently adapted solely and especially for holding works of small dimensions.

The last tool of this description, of which we shall speak in this place, is a variety of the ordinary outside spring-chuck.

This apparatus is formed in a similar manner to the ordinary spring-chuck, but, instead of being constructed in brass, it is formed by gluing together various concentric layers of stiff paper. The object of this chuck is to hold certain very delicate materials, such as the egg-shells of birds and reptiles, for the turning of which on arbor is also required.

We will now describe a different form of centre from those ordinarily used. These centres are called spherical centres, and may be made either hollow or solid. The former consists of the ordinary tang, but

instead of the sharp conical point there is a spherical cup, which is suitable for sustaining articles with spherical ends.

If, on the contrary, the work to be supported is formed with hollow spherical ends, the hollow spherical segments on the above centre tangs will be replaced by solid spheres.

We will now turn our attention to the apparatus employed for grinding the facets of cutting-tools, &c., and also for chasing the precious stones.

The former of these instruments are commonly called laps. They are made of a material somewhat softer than that which is intended by means of them to be ground or polished, and the object of its being thus softer than the work to be manipulated is, that, when the two are rubbed together, a gritty material being interposed between them, this material may embed itself in the lap, where it will be firmly fixed with one or more solid angles protruding to cut or abrade the work.

These laps may conveniently be made of an alloy consisting of lead and antimony, in the proportion of nine and a half of lead to one of antimony. This alloy is soft to cut, but capable of being turned to a bright surface, almost inflexible, but somewhat brittle, and the most convenient method of forming the lap will be by casting a face of the lap-metal on to an iron chuck.

Fig. 70.

When the metal, by its contraction, will take a firm hold of the iron—a section of this apparatus is shown in fig. 70—where the soft metal is represented by the shaded part. These laps may, however, if made thick or of small diameter, be made to stand without the iron back. In any case, the lap should be turned true and bright before it is used.

The above-mentioned metal may be mixed, and also subsequently melted, over an ordinary fire, but antimony cannot be melted alone over an ordinary fire, on account of the highest temperature obtainable from this source of heat being insufficient for that purpose; nevertheless, if the lead be first melted, and the antimony, having been broken up, be place ed in it, and the mixture occasionally stirred, it will be found that the lead will dissolve the antimony.

We next have to examine the materials which we shall have to use with the above tools for reducing or polishing of any desired article.

These powders should be used in the following order: First emery, then crocus, or some equally fine powder, and finally some finer powder, such as putty, &c.

There are some other powders also used for the above purposes; namely, diamond-dust, powders of the various oil-stones, and some other similar substances.

It will be advisable, whenever it can conveniently

be done, for the amateur to prepare for himself such abrasive substances as he may require, as he will thereby avoid the inconvenience occasioned by such inferior and adulterated articles as are commonly supplied by the dealers, an eminent instance of which is observed in the large amount of coke-dust, &c., which is retailed under the name of emery-powder.

The mineral from which emery is derived is dense, heavy, and very dark-coloured, and it should be prepared for use in the following manner:

The mineral should first be broken into small fragments, then ground by means of an edge-runner, or other suitable contrivance. The powder thus obtained should be passed through sieves of various sizes, whereby it may be classed according to its degree of fineness. The finest thus obtained may be reduced to an impalpable powder in a small mortar, and reserved for very delicate work.

If it is intended to prepare emery cloth, it should be done in the following manner: The cloth, being stretched, should be brushed over with size; after which, emery of the required degree of fineness should be shaken on to it from a sieve whose meshes are of a size corresponding to the fineness of the emery used. When the cloth thus prepared is dry, the operation may be repeated, until the emery is collected on the cloth in sufficient quantity.

For smoothing wood, glass cloth is generally used where the work is of importance, and this may be

prepared in the same manner as the emery cloth, with the obvious substitution of powdered glass for that mineral.

The other polishing powders may usually be obtained in a state of tolerable purity. Crocus is an oxide of iron, and putty-powder is a preparation of tin.

For purposes requiring great delicacy, the crocus should be specially prepared, and we deem the following process extremely satisfactory for this purpose:

Take of pure crystallised sulphate of iron, otherwise called green vitriol, any convenient quantity, and dissolve this in a sufficient amount of pure water: that is to say, water which is clear of any kind of grit. Take an equal quantity of pure carbonate of soda, which dissolve in another vessel, also in pure water. This being done, filter each solution through white blotting-paper, then mix the two filtrates, and agitate the mixture. After a few minutes a precipitate or sediment will be observed to have formed at the bottom of the vessel. This precipitate is now to be removed, which may be done by pouring the contents of the vessel on to a filter of the same material as the above-mentioned. The clear liquor will pass freely through, but the precipitate will be retained upon the filter, and is the only part which will be of any service to us. The filtrate which contains the soda salt may be thrown away, but the precipitate in the filter must be carefully dried; after which it is to be raised to a red heat in a clean

vessel. This will furnish an exceedingly fine smooth species of crocus-powder, perfectly free from all kinds of grit, and highly suitable for polishing lenses and other works requiring an exquisite surface.

We may here, for the benefit of those who are not accustomed to such manipulations, explain the manner in which the filter paper should be folded.

Fig. 71.

The paper should first be cut into a circular form, and then folded in half, and subsequently into small sectors, commencing as shown at *a*, fig. 71, and continuing this process until the filter presents the appearance of a closed fan, shown at *b*. It may then be opened out into the form of a fluted cone, when, on viewing it from above, it will present the appearance shown at *c*. This is to be placed within a glass or porcelain funnel, and the contents of the vessel in which the precipitate was formed are to be poured upon it. When folding the filter it is necessary to abstain from making the folds or plaits extend quite to the centre of the paper, as by such a proceeding an aperture would be almost certain to be formed there, and through this the precipitate would escape. The principle upon which this pro-

cess depends is the minuteness of the particles into which the various ingredients are divided by solution, and it is for the purpose of getting rid of any insoluble matters which may be present in either the salts or the water that the two solutions are filtered previous to their being mixed.

The material resulting from this process may be used either dry, or with oil or water.

We will now give a brief account of the method of preparing putty-powder. This powder is an oxide of tin, or of tin and lead, the best consisting of pure oxide of tin, but as the manufacture of this latter is somewhat difficult, the oxidation is assisted by the addition of a small quantity of lead, for which purpose the linings of tea-chests are employed, or an alloy prepared in ingots by the pewterers, and termed shruf.

Common putty-powder, of good fair quality, should be prepared from equal parts of tin and lead, or tin and shruf. The inferior dark-coloured kinds are made from lead only.

Putty-powder is prepared by placing the metal in an iron muffle kept at a red heat; the metal fuses, and oxide forms on its surface; it is frequently stirred, to expose fresh surfaces to the air. When all the metal has disappeared the process is at an end, and the particles on the upper part of the oxide appear like incandescent charcoal. The oxide is removed in ladles, and spread out in iron cooling-pans. Hard

lumps of the oxide are then selected and ground dry under an edge-runner, and the powder thus produced is sifted through lawn.

The putty-powder used by Mr. A. Ross, the optician, is prepared as follows: Metallic tin is dissolved in nitro-muriatic acid, and precipitated from the filtered solution by liquid ammonia, both being largely diluted with water. The peroxide of tin is washed with plenty of water, collected on a cloth filter, and squeezed as dry as possible in a new linen cloth, after which more of the moisture is removed by submitting it to the action of a screw-press. The lump thus obtained is broken up, dried in the air, and finally levigated on a glass plate with an iron spatula, and exposed in a crucible to a low white heat.

This powder does not cut with any keenness before it is heated, but this heating renders it anhydrous, when its particles assume the form of lamellar crystals, which cut with far more energy, but without producing any scratchy appearance. The fineness, of this powder depends upon the same principle as that of the crocus.

Various other materials, which we shall not stop to describe, may also be used for grinding and polishing such as corundum, rotten-stone, flint, tripoli, pumice-stone, chalk, &c.

We will now pass on to a description of those apparatus employed for the chasing of precious stones.

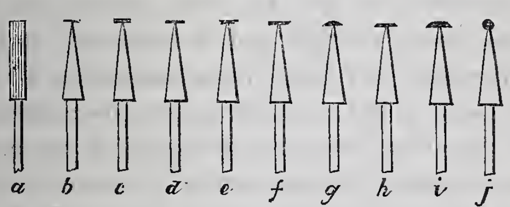
Some materials which are too obdurate to admit of being cut by an edged tool, may be cut by a slicer furnished with diamond-powder, which slicer is, during the whole operation, kept well supplied with oil of brick. This oil is made by soaking some porous mineral, such as brick, in oil, and distilling the oil off.

All precious stones inferior in hardness to the diamond, admit of being engraved, and even the diamond itself has been so manipulated.

The softer stones can be cut with great rapidity, but the effect is not so smooth as in the case of the hard stones.

The tools used by the engraver of precious stones are represented in fig. 72.

Fig. 72.



They consist of a series of very minute laps. They are fixed on to long conical mandrils, which fit into the hollow mandril or quill of a small pillar lathe-head. This head consists of a brass pillar, six inches high, with a bolt at the bottom, by means of which it is attached to the work-bench, where it is

retained by a nut. At the upper part of the pillar are two openings which cross at right angles, and are for the reception of the pully and the bearings of the quill. The quill is of steel, about two inches long and half an inch in diameter; it is hollow for the whole of its length, and on one side of the interior surface is cut a groove or slot, into which passes the feather on the stem of the lap.

The forms of these tools are very various, but the general form is that of a minute disc, more or less rounded on the edges, which is the part used for cutting.

For cutting fine lines the edge is nearly as thin as that of a knife; a thicker and more rounded edge is used for thicker lines.

For sinking large shields the tools are considerably rounded, and in some cases almost spherical. The rounded tool cuts far more rapidly than one with merely a flat edge, and is commonly used for removing the chief bulk of the material, while the flatter edge is had recourse to for smoothing the work. To allow the tool to be applied to flat sunken surfaces, without the stem coming in contact with the work, the stem is made conical, as at *e* in figure. The tools, *b*, *c*, *d*, *e*, are seldom larger than the sixth of an inch in diameter, and they are frequently made so small as not to exceed the hundred and fiftieth of an inch in diameter, and when of this size the tool can scarcely be distinguished by the naked eye from the stem.

These tools, when so very minute, cannot be formed by the file alone, but must be used on works of larger size until worn down small enough for the purposes for the execution of which they are designed.

These diminutive laps are used with a mixture of diamond dust and olive-oil. The paste thus produced is kept in a small conical cup, which is occasionally applied to the tool. The diamond paste is applied to the extreme edge of the tool while in slow motion; the tool is then moistened with oil of bricks or sperm-oil, and the cutting proceeded with till the oil is evaporated. The tool must not be allowed to become too dry, or the diamond paste will become detached, and the tool will be cut instead of the work.

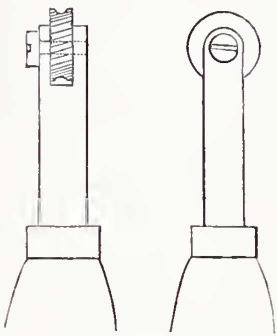
These tools are made of copper, which is a material whose softness renders it suitable for this purpose, both on account of the ease with which it may be cut, and also by reason of the angular particles of diamond being able to embed themselves regularly and firmly in the lap.

There are various methods employed in the finishing of works, one of which is that by which a curled or mottled aspect may be produced on nuts, &c., which is effected by the immersion of these articles in weak acid, whereby the softer parts of the surface are removed, producing thereby the above-mentioned appearance. A mottled surface may also be produced upon metal by the use of a scraper, which latter may conveniently be formed from an old three-

edged file, of which the teeth are ground off, and the extremity rounded off to a point; three curved edges will thus be produced, each edge containing between its facets an angle of 60 deg.

It is frequently requisite, or at least desirable, to mill the edges of screw-heads, tops of small boxes, &c., and this is readily done by means of an instrument called a milling-tool.

Fig. 73.



The accompanying sketches in fig. 73 represent a front and a side elevation of the ordinary milling-tool. It consists of a steel wheel with a grooved periphery, in which are also cut various other grooves, in the direction of the axis of the wheel. The wheel is mounted on a screw, passing through the two sides of a forked piece of iron. The wheel is made of steel, and may be cut by means of a small hob, which is a screw of the form corresponding to that of the milling-tool, but with a portion of its thread removed to form cutting edges. This hob being fixed in the lathe and caused to revolve, the worm-wheel is placed against it so that the two work together after the manner of a worm-wheel and tangent-screw, and the action is maintained until the wheel is accurately

cut; it is then removed from its bearings and carefully hardened, when it is remounted in the iron fork, to which is attached a suitable handle, and the tool is then ready for use. The action of this tool is partly by cutting and partly squeezing the work into form, and it should be continued until the work is accurately milled on every portion of its circumference.

There are some other methods of ornamentation which we may here consider the means of effecting.

The principle of the ordinary chuck consists in its motion being of such a nature that all work turned upon it is, if the tool be stationary, reduced to a circular form. If, therefore, we wish to produce figured patterns, we must impart a movement either to the lathe-mandril or to the tool, or otherwise to some apparatus to which the work is attached, and which itself is fixed upon a chuck, but is capable of motion with regard to it.

The various tools used for the purpose of producing figured designs are included in the following. The eccentric chuck, by means of which circular forms are also produced, are not only concentric with the lathe-mandril, but may also have their centres shifted as frequently as may be desired, whereby very pleasing effect may be produced. The oval or elliptic chuck describes oval figures; of which the deviation from the circular form, and the position,

with regard to the direction of the axis, may be varied.

The geometric and compound eccentric chucks produce various beautiful curved designs. The oblique and epicycloidal chucks also turn curious and intricate patterns; and the straight-line chuck performs all its work in a straight direction.

These chucks may be so combined as to produce a never-ending variety of beautiful forms, but many of them are exceedingly complicated in construction, and consequently very expensive. One of them, of peculiar form and very intricate, has been employed for the purpose of designing patterns on country bank-notes and cheques, in order to prevent them from being fraudulently imitated.

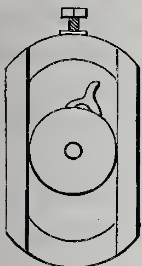
In the art of ornamental turning there are two objects to be attained, one, the production of extremely elegant designs, and the other the execution of difficult forms..

Those who have had much experience in the method of using these tools, can produce a great variety of carved works, such as brooches, chessmen, and ornamental vases full of detached flowers.

The eccentric chuck will be found a useful addition to the lathe, for, by its means, the centre of the work may be changed at pleasure, but in the use of this, and other similar apparatus, the cutting-tool should be secured in a slide-rest, otherwise exactness and delicacy of work cannot be ensured; moreover,

with the eccentric chuck the sizes of the circles are determined by the slide-rest, whilst the chuck itself fixes the position of their centres.

Fig. 74.



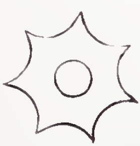
A front view of the ordinary eccentric chuck is shown in the accompanying figure. It has at the back a socket, by which it may be attached to the lathe-mandril, and to this socket is immovably fixed a chuck, which carries the moving part of the apparatus. On the front of the chuck is formed a broad, dovetailed groove, the sides of which are made of separate pieces screwed on to the chuck; in this groove is fitted a slider, which carries a pin, upon which is a circular plate free to revolve on its axis; a screw projects from the front of this circle for the attachment of ordinary chucks. A screw is also provided by which the slider may be gradually moved in the groove, and which firmly retains it in any required position. By means of this screw the circular plate may be made to coincide, as regards its axis, with the lathe-mandril, or it may be set with any required degree of eccentricity from the mandril. The circular plate is divided on the edge into equi-distant teeth, and a pall or catch is attached to the slider by a screw, so that it may be inserted into any of the teeth at pleasure, whereby the circle is prevented from revolving on its own axis.

A small instrument termed an eccentric cutter, which may be worked by a drill-bow, is frequently used by the ivory turner; it is similar in principle to the foregoing chuck.

Elliptical turning is performed by a chuck of peculiar construction invented by Abraham Sharp. It consists of three parts—the chuck, the slider, and the eccentric circle. The chuck is secured to the mandril by a screw- socket, so that the chuck partakes of the circular motion of the mandril. Upon this chuck is formed a broad dovetailed groove similar to that of the foregoing, and within this groove is a slider, the centre of which carries a screw for the reception of a chuck which holds the work. An eccentric ring, or circle, is attached to the poppet-head of the lathe, by means of which a sliding motion as well as a rotatory one is imparted to the slider, thereby generating an ellipse; the whole is adjusted by means of set screws.

This chuck should be provided with a click-plate, by means of which the ellipses may be placed in various positions.

Fig. 75.



We will now turn our attention to the construction of the rose-engine, and also to that of some substitutes for this machine. The rose-engine is intended to produce a number of concentric figures similar to that shown in fig. 75, but having any number of concave

segments that may be required, the figures being all of them concentric.

The rose-engine may be described as a variety of lathe, having a front poppet-head, which, instead of being fixed, is capable of oscillating laterally, this oscillation being regulated by an apparatus called a rosette, the form of which is shown in the accompanying fig. 75. The poppet-head is drawn to one side by means of a weight attached to one end of a cord passing over a pully, the other end of which is attached to the poppet-head, which keeps it close against an adjustable roller. It is thus used: A rosette of the proper form and size having been selected, it is attached to the mandril, and the roller adjusted so that the rosette may work against it, the engine will then be ready for use.

The effects of the rose-engine may also be produced without using that apparatus, by causing the rest which carries the tool to oscillate in a similar manner to the poppet-head of the rose-engine; the method of accomplishing this is so self-evident that it would be a work of supererogation here to detail it.

We may here give a description of the apparatus requisite for the execution of that elegant process invented by Mr. Kittoe, used for the production of work turned from egg-shells.

The first part of this apparatus is a light paper spring-chuck; it is formed by rolling stout paper,

thoroughly moistened with glue, upon a metal or hard-wood cylinder, the surface of which has been previously greased, in order to prevent the paper from adhering to it, and upon which it must be allowed to remain until it has become perfectly dry, when it may be removed and cut, or turned in the lathe, as occasion may require. This chuck is used to hold the egg during the period of its preparation for the chuck about to be described; before using it, the inner surface should be rubbed with some adhesive substance, such as diachylon.

The chuck in which the shell is turned is thus made: A chuck is first prepared of box, or other hard wood, and into this is fitted a piece of cork, or soft material, against which the egg-shell may rest, without danger of its being broken. In the centre of this chuck is fixed a piece of brass, and into this is screwed a fine steel wire, the outer end of which is also cut into a screw, which is provided with a nut. A cup-shaped piece of hard wood, within which is fitted a piece of cork, which answers the same purpose as that which is fitted to the chuck, must also be provided, capable of sliding upon the steel wire.

The egg-shell is thus chucked: The piece of steel wire being firmly fixed in its place, it is passed through the shell to be operated upon, and the cup being passed over the end of the screw, it is brought to such a position that is bears firmly upon the shell to be

turned, and when thus arranged it is retained in position by means of the screw-nut.

Having now described in detail such apparatus as the amateur wood-turner is likely to require, we think it not undesirable to give him some information with regard to working in metal, in order to enable him to construct such tools and other apparatus as he may require, without calling in the aid of a professed mechanician.

We will commence with the construction of such apparatus as are formed in cast metal, but as it is highly improbable that the amateur would be provided with the necessary apparatus, even if possessed with the desire of executing such works entirely, the only parts of these operations which demand our attention are the formation of the pattern or models, and the completion of the work after it has been cast.

The pattern which we first have to consider will, however, require on the part of the amateur a certain degree of acquaintance with the processes which they are designed to supply the means of executing.

The casting of various forms is entirely effected by pouring the material of which the article required is to be formed, while in a liquid state, into a cavity, which is a counterpart of the article to be produced, of dimensions somewhat greater; thus, if we desire an article to be produced in cast-iron, the length of

which is to be five feet, it will be necessary to construct a model or pattern of which the length is five feet and half an inch, hence it is necessary to allow one-tenth of an inch in every foot for the contraction of iron works, while their temperature is diminishing from the point of liquefaction to the ordinary temperature of our atmosphere. Another point which also requires to be carefully attended to, is the formation of the pattern in such a manner as will admit of its ready withdrawal from the sand of which the mould is composed; to effect this, it will sometimes be found necessary to form the pattern in many pieces, which fit together and are retained accurately in their places by means of set-pins, otherwise it will be found impossible, on account of the undercuts and apertures, to remove it from the sand.

Another method which is resorted to, consists in the formation of numerous pieces called cores, which are inserted into the mould after the removal of the pattern, and which, projecting into the cavity, produce recesses or apertures as may be required.

We may select as a specimen of pattern-making, the construction of the model required to enable the founder to produce a casting for the back poppet-head of an ordinary lathe.

The form of this piece of apparatus has been already described in the first chapter of the present treatise. The pattern may be made of deal, similar to the desired casting in all respects, except that the cylindrical

hole required through the latter is not formed in the pattern, but, on the contrary, cylindrical pieces of wood somewhat less in diameter than the required aperture, which are called prints, are to be attached to each end of the pattern in a position concentric with that of the required hole.

The pattern being thus constructed somewhat larger than the intended casting, the moulder embeds it half way in a box of moulding sand, and the surface of the sand being smoothed, it is sprinkled with charcoal-dust; and the upper part of the box or flask, which, like the lower, consists of only four sides, being open at both ends, is fitted upon the lower part by means of steady-pins fixed in lugs in one part of the flask, and fitting into corresponding apertures in lugs on the other part of the flask. This being done, the upper part of the flask is filled up with sand, which is rammed carefully down. The flask is then inverted, that part which was at the bottom being now at the top: it is tapped with some hard substance in order to detach the pattern from the sand. The upper part of the flask is now removed, the sand which it contained turned out, after which it is replaced upon the lower part of the flask, and the surface of the lower mould having been again dusted with charcoal, the flask is filled up with sand; but this time conical pegs are first rested upon the pattern to form entrances to the cavity for the ingress of the molten metal, and exits to allow of the egress of the

air and other gases; it is also occasionally found necessary to screw into the pattern one or more pieces of stout wire, which, projecting above the surface of the sand may be struck with a hammer in order to loosen the pattern; if this is done, the wires are unscrewed from the pattern previous to the removal of the upper part of the flask. The upper part of the flask being lifted off, it is inverted, and if the impression produced therein is defective, it is repaired by means of a small trowel of a suitable form. The pattern is then removed from the sand in the lower part of the flask, and the impression there produced is perfected in the same manner as that in the upper flask. A cylindrical core, previously formed of sand and clay, in diameter equal to the core-prints above mentioned, and in length somewhat greater than the aperture to be formed in the poppet-head, is placed in the mould in such a manner that it is supported at its ends by the recesses formed by the core-prints, and it is, if necessary, formed upon a metal bar, to afford sufficient strength, and also nails are sometimes requisite to retain it in position. The upper flask is now replaced, and all that remains to be done is the casting or pouring of the metal of which the desired object is to be formed; but of this we do not purpose treating in the present work, as the various methods of founding will not be required by the amateur.

The casting being formed, and the superfluous metal struck off, the first step in the further prepara-

tion of the work consists in the partial removal of the coating of sand, which has become attached to the casting, and which is partially vitrified by reason of the heat of the molten metal. This is removed by rubbing the rough casting with a piece of hard oven coke, and still further smoothed down with an old coarse file.

In this state the work comes into the hands of the amateur, and for the removal of the remainder of the hard coat, at such places as may be required, he should use turning-tools with very obtuse edges. The parts which will require to be thus operated upon are the ends of the cylindrical part of the poppet-head, the bottom of the poppet-head, and the interior of the cylindrical part, and the boss which is to be tapped for the reception of the set-screw, by which the mandril may be retained in any required position.

The bottom of the slide-rest may first be planed or wrought to a true surface by means of the file, chipping-chisel, and scraper, which latter is used to remove the slight inequalities left by the file, the use of which is regulated by trying the work on the surface-plate.

The surface-plate, or planometer, consists of a rigid cast-iron plate, the surface of which is reduced to a condition as nearly approaching that of a true plane as possible. It is thus used:

The surface of the planometer being smeared over with ruddle or other colouring matter, the work, the

truth of which is to be ascertained, is rubbed upon it, when it is evident that those points of the work which are highest will alone rest upon the surface-plate, and these points will gather up a portion of the ruddle, wherby their position will be indicated. The parts which are thus coloured must now be scraped down, whereby other more numerous points of the surface of the work will be brought into contact with the surface-plate, when the work is again applied to it. This operation is repeated until the work is reduced to a surface sufficiently accurate for the purpose for which it is intended.

The head is then placed upon the lathe-bed, and the cylindrical aperture bored out first with a rough tool, and finally with a more delicate one. The method of conducting this process is as follows: A small boring bar, with one or more slots in it, is placed between the lathe-centres, a carrier being attached to one end, which is acted upon by a pin fixed in a face-plate; in the slot of this boring-bar is fixed the cutter, in such a position that it will produce an aperture of the required dimensions; as the hole is bored the work is caused to progress, so that the tool may act through-out its required length.

Having now given instruction for the preparation of a poppet head, it remains to be observed that the same method will have to be followed out in all cases where a finished surface is to be wrought upon a casting, whether it be of iron, of brass, or of other material.

We may now give some instructions with regard to the manipulations which must be employed for the production of articles in wrought-iron.

The first process to which we must call the reader's attention is that of forging. We will select as a specimen of this art the construction of the mandril and screw, intended to be fitted into the back poppet-head.

A piece of good bar-iron being selected of a suitable diameter, it is heated and cut to the required length, when it will be ready for the hands of the turner. The screw, however, will require to be forged with a collar upon it. This is done by heating the metal up to the place where the collar is to be formed, cooling the end by immersion in water, and striking the bar endways, a process which is termed „upsetting the metal," and one by means of which the latter is caused to bulge out at its softest— that is, at its hottest part. When the operator considers that the work is sufficiently upset, the form of the collar may be completed by placing the heated work between properly-formed dies, called swage-tools, the upper one of which is struck with a sledge-hammer, the work being caused to perform a part of a revolution in the intervals between the blows. When the collar has been thus reduced to a suitable form, the remaining parts of the forging may be completed between plain semi-cylindrical swage-tools.

The turner may now proceed to finish the works

for which these forgings have been prepared. For this purpose he may place the larger forging between the lathe-centres, and reduce it to a cylindrical form of the required dimensions by a tool having a cutting edge, whose facets include an angle of about 85 deg., which must be supplied during the process with a solution of soft soap.

This being accomplished, that end of the work which formerly rested against the back centre of the lathe is placed within one of the apertures of the boring-collar, and a drill of suitable size caused to press against the end of the work, by which means an aperture is drilled nearly through its length. It may then be reversed, and a hole of the same diameter bored from the other end, up to the termination of the first hole. The centre part of this cylindrical hole should be bored out larger than the extremities, so that at one end a thread may be cut in which the propelling and withdrawing screw may gear, and at the other a taper hole will be bored to receive the centre.

We now have to consider the means to be adopted for the completion of the screw wherewith the centre may be adjusted. The screw-blank is to be placed between the lathe-centres, its revolution being ensured be means of a carrier. The collar may then be reduced to its proper form and dimensions, the rest of the work being reduced to a truly cylindrical form.

The screw may now be cut according to one of the

methods already detailed in the chapter on screw-cutting. This being done, the screw is inserted within the poppet-head, so that the collar fits into a recess turned in the back of the poppet-head for its reception, and it is retained there by means of a flat ring or washer screwed to the back of the poppet-head. The means by which the screw is to be worked, whether it be a handle or a wheel, is now to be attached to the end of the screw, and the mandril being inserted at the other end of the poppet-head, it is caused to gear with the screw; but as the mandril might revolve with the screw, instead of progressing upon it, a groove should be cut in the bottom of the former, in which a stop attached to the bottom of the cylindrical hole in the poppet-head may work; and if it be desired to prevent the mandril from protruding beyond a fixed distance, the groove should be cut on the bottom of the mandril, corresponding to the length of this distance; and the mandril thus prepared should be introduced at the back end of the poppet-head, previous to the insertion of the screw. The set-screw, by which the mandril is retained in any desired position, should be made to act upon the mandril by pressing upon a square piece of metal inserted in a recess beneath the set-screw, as if the screw be allowed to act directly upon the mandril, it would be very liable to produce indentations thereon.

The centre is fixed in the mandril by a few light

blows from a hand-hammer, a piece of wood being placed against the point of the centre to protect it from injury. When it is required to remove the centre from the mandril, this may be done by working the latter back into the poppet-head, until the end of the screw comes into contact with the tail of the centre, thereby forcing the latter from the mandril.

As the amateur may have occasion to graduate various pieces of work, such as click-plates, &c., we shall now explain some method of accomplishing this operation.

The art of graduation may be divided into three classes—first, common graduation; second, engine graduation; third, original graduation.

Common graduation consists in dividing the work to be operated upon, by means of a pattern which has been already laid down by means of original graduation; but, as a general rule, the process of common graduation consists in taking copies of a copy. It also includes those cases where the usual patterns cannot be applied, and where the highest degree of accuracy is not indispensable.

The apparatus which is required to regulate the division of circular work, is termed a dividing-plate. It consists either of a complete disc, or of a broad rim connected with the centre by means of rigid radial arms, and made inflexible by means of rings or circular feathers within the rings. Its diameter may vary from five to thirty inches, according to the

purpose for which it is designed, the larger discs being most easily divided accurately.

The ordinary dividing-plates are graduated as required for the production of the various divided circles used in the construction of theodolites, perambulators, compasses, &c., but those of which we shall here treat do not require such delicate workmanship as these.

The dividing-plate, when not intended for use with the lathe, is thus fitted: In the centre of the plate is bored a circular hole, truly cylindrical and perpendicular to the surface of the plate, into which is accurately fitted a pin or arbor, which also fits accurately a centre hole in the circle or arc which it is desired to divide, and this pin or arbor forms the principal connexion between the work to be graduated and the dividing circle by which the graduation is regulated during the period occupied by the process of graduation.

The dividing-plate is prevented from shifting upon the work by clamping the two firmly together by means of holdfasts, two or more being used, as it will be necessary to move them when their position obstructs the process of the work.

A steel index, with a very accurate straight-edge, is attached at one end to a piece of brass, in which is cut an angular notch, which would be exactly bisected by a continuation of the straight-edge, which notch being rested against the arbor, directs the

straight-edge to the centre. The length of the index is equal to the radius of dividing-plate. At and below the exterior end of the straight-edge, a secondary index is usually attached, of which the edge is also directed to the centre of the dividing-plate, the edge reaching from the exterior of the dividing-plate, as far towards the centre as the divisions extend. This edge is usually placed a little in advance of the straight-edge.

This apparatus is usually furnished with various set-screws, by means of which the secondary index may be adjusted to suit the thickness of the work, in such a manner that its edge may rest flat and true on the work to be operated upon.

For graduating work with a chamfered edge, a flexible index is sometimes used, so that, by the pressure of the hand, it may be caused to lay flat upon the circle or arc to be graduated, but it will be found far more satisfactory to use the secondary index provided with set-screws.

All that now remains to be described in connexion with this apparatus is the dividing-knife: It consists of a short steel blade, having a semi-circular edge, the radius of the semi-circle being equal to half the width of the line which the knife is required to make. The end of the blade is to be ground so that it will make an angle with the edge of the blade equal to about 110 deg. The left-hand side of the blade should be ground perfectly flat, and the other side somewhat

rounding, the thickness of the back of the blade being about one-sixteenth of an inch. A semi-circular piece is cut out from the edge of the blade in order to render the grinding of the tool more easy of execution, and in which the finger of the operator may be rested when using the knife. The ferrule is also partly cut away, in order to allow the tool to be more conveniently handled. The knife is held in a very similar manner to an ordinary pen, but the handle must be quite home between the thumb and forefinger, which latter, being placed upon the ferrule directly over the back of the blade, is by its pressure, the chief agent in giving depth to the divisions, the thumb and middle finger being used to support the blade, while the remaining fingers, as in ordinary writing, prop the hand. The knife is held at about an angle of 45 deg. with the surface to be divided, and is used with the flat side in contact with the index of the dividing-plate. The principle of this tool is the reverse of that of the graver, which latter, being pushed forwards, cuts away a fibre in the line of its action, leaving the rest of the material undisturbed; whereas the knife is drawn towards the operator, and, without producing chips or shavings, it leaves a groove, the displaced metal rising up in a burr on each side, which burrs are afterwards removed by polishing the work with willow-charcoal and water.

Before cutting the radial grooves which indicate

the divisions, the circular lines which limit the length of the strokes are marked out by means of a beam-compass, and a groove cut in the position thus indicated by the dividing-knife

Common dividing is also applied to straight lines as well as to circular, but in this case the pattern is, of course, straight.

The scale on which the copy is to be laid is placed beside the pattern, and instead of the index above described, a dividing square is used. This set square consists of a well-tempered steel straight-edge, fixed at right angles into a stock; it is made to slide along the original, stopping at each division when a corresponding stroke is cut by the dividing-knife on the copy.

When box or other wood has been divided, the burr is first well rubbed off the divisions, and the whole surface is then polished with a dry rush; the surface may then be burnished by rubbing it hard in both directions, parallel to the grain of the wood with a clean piece of an old hat, thereby producing an agreeable gloss.

The divisions may be blackened by a mixture of powdered charcoal and linseed oil, laid on quickly, ubbed hard, and cleared away; this finishes the process.

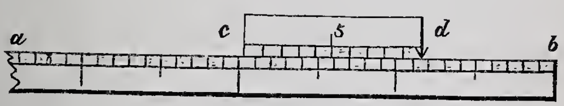
If ivory is the material divided upon, a different mixture must be used for filling up the divisions. These divisions are first filled in with a composition of

hard tallow, or beeswax and olive-oil, and when this has been rubbed well into the strokes the whole surface is to be well polished with rush, and finally finished with chalk and water laid upon a linen rag. In finishing brass which has been divided upon, the burr should first be removed with charcoal and water, and the surface then finished off with wet blue-stone, which is a very soft kind of slate.

Divided gold and silver may conveniently be finished off with charcoal; but all the metals are improved by being rubbed with the hand ofter a little oil has been applied.

We may here describe the method of using some of the divided scales and plates. If dimensions are required, which must not necessarily be taken with extreme accuracy, a simple scale will be sufficient, from which scale any required dimension may be taken off by compasses or dividers; but if a greater degree of delicacy is required, we must provide ourselves with a vernier, the principle of which we will now explain.

Fig. 76.



Let us suppose that we desire a scale by means of

which we may accurately take dimensions to a hundredth of an inch.

Let *a b*, fig. 76, represent a scale carefully graduated into inches and tenths as shown, and let *c d* represent the vernier; this vernier has upon it a scale divided into ten equal parts of such dimensions that the ten divisions of the vernier are equal to eleven divisions of the scale *a b*, then it is evident that each division on the vernier is equal to one and a tenth division on scale, or to eleven-hundredths of an inch.

To use this instrument, we must notice that division of the vernier which corresponds with the division on the scale and count the number between that and zero on the vernier; thus, if we wish to ascertain the distance of the zero point of the vernier, as shown in the sketch from the point *a* on the scale, we observe that it is something more than 4.1 inches, and we also notice that the fourth division of the vernier corresponds with the division on the scale, therefore progressing towards *d*; the next division to the fourth is 0.01 inch in advance of the next division on the scale; the next division on the vernier will be 0.02 inch in advance of the next division on the scale, each division of the vernier adding an increase of 0.01 inch advance beyond that division of the scale which is just behind it: wherefore at the zero point we shall have gained a quantity beyond the last division on the scale, which is included in the measurement, equal to 0.04 inch, whence we immediately

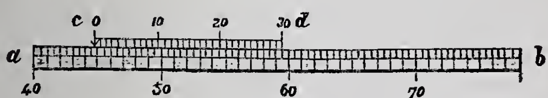
obtain the required measurement, which is in the present case equal to 4.14 inches.

It is very evident that by properly adapting our vernier we may obtain measurements to an extreme degree of accuracy.

It will generally be found more convenient to read the vernier in the same direction as we do the scale, instead of retracing our steps in order to find the point at which two divisions are in the same straight line, and this may be done by constructing the vernier in the following manner.

Fig. 77 represents a portion of the divided circle of an ordinary theodolite, which is required to be read with accuracy to one minute of a degree.

Fig. 77.



Let *a b* represent a portion of a graduated periphery of the divided circle of an ordinary theodolite, *c d* being the vernier of which the zero is at the end; *c*, the circle, is divided into degrees, and half-degrees, and the vernier is so constructed that thirty of its divisions are equal to twenty nine of those divisions, each of which represent half a degree, thus each division of the vernier is one minute short of one of the smaller divisions of the graduated circle.

The scale is thus used. The theodolite being set as shown in the sketch, we find that the zero point of the vernier stands at something more than 44½ deg., and, by looking along the vernier, we find that the twenty first division corresponds with the division of the graduated circle, hence we conclude that the zero point of the vernier stands at 44 deg. 51 min., which may thus be proved: The twentieth division of the vernier is one minute in advance of the nearest division on the graduated circle, the nineteenth division of the vernier is two minutes in advance of the nearest division of the vernier, and thus for every division on the vernier towards zero we gain one minute in the advance of the last division on the graduated circle; hence at the zero of the vernier, which is twenty-one divisions from the point at which the vernier and the graduated circle correspond, we are twenty-one minutes in advance of the last division on the graduated circle, which is that indicating 44 deg. 30 min., which gives us the position required at 44 deg. 51 min.

This principle may evidently be applied to a great variety of purposes; but we have selected the present case as being the most convenient.

We may now describe the beam-compass, which is used for marking out the circles on plates which are to be divided.

This instrument consists of a beam of any required length, generally made of well-seasoned mahogany;

upon its face, is inlaid throughout its whole length, a slip of box, holly, or ivory, on which are engraved the divisions of the scale.

Two brass boxes are adapted to the beam, each carrying a fine point; one of these boxes is firmly fixed to one end of the beam, and the other is capable of sliding upon it, being provided with a set-screw, by means of which it may be retained in any required position, the distance between the points being regulated by means of verniers attached to the boxes. When very great accuracy is required, the point of the fixed box is attached to it by means of a slide which may be moved by means of a slow motion screw, whereby a very great nicety of adjustment may be obtained.

For some descriptions of dividing, the compasses called spring-dividers will be found useful. They consist of a circular steel bow and two legs, all in one piece; the bow is spring-tempered and tends to retain the points about one or two inches asunder, a screw is attached to one of the legs by a pin passing through it, and passes through a hole in the other leg; it is furnished with a nut by which the points of the dividers may be set at any required distance within the range of the instruments. The legs are bored at the end to receive the cylinders or points, which are afterwards reduced to the requisite degree of fineness; the points being brought very near the inner extremities of the diameters of the cylinders in order

that they may measure as small a distance as possible, but at the extreme points they are made round, and in every direction the sides must make equal angles with the perpendicular, otherwise a distance set off with the dividers would be altered by pressure.

In using the dividers for accurate work a magnifying-glass held in the left hand should be employed.

Engine-dividing now demands our attention. Under this head we shall include not only engine-dividing properly so called, but also the process of dividing by means of the common lathe, but when this apparatus is used we must have some special pattern as a guide, and it is on the whole very similar to common graduation.

The basis of most, if not all, of those machines called dividing-engines, was that invented by Ramsden, and of this we shall give a brief description.

An horizontal circle or wheel, four feet in diameter, is fixed upon a vertical axis, and its edge is cut into teeth, notches, or worms, and into the edge of this circle gears a screw, thus forming that arrangement which is known by the same of worm-wheel and tangent-screw, and they are so proportioned that one revolution of the tangent-screw causes the circle to revolve through a distance equal to 10 min.; the pressure of the foot upon the treddle turns the screw forward, and by a series of ingenious contrivances the operator is enabled to turn the screw through any desired portion of a revolution at each descent of the

treddle. When the foot is removed from the treddle the latter regains its position, but without allowing any return motion of the screw; the circle to be divided is fixed upon the dividing-engine, and made concentric with it, and a division is cut after each pressure of the foot.

Mr. Edward Troughton contrived a dividing-engine, which was completed in 1793. In this instrument, as in Ramsden's the large dividing-wheel was worked by a tangent-screw, one revolution of which carried the circle through a distance of 10 min. The tangent-screw had twenty threads to an inch, hence it followed that the circumference of the dividing-plate should be 108 inches; in graduating this instrument, a microscope furnished with a cross wire was used.

Mr. Simms, noticing that Troughton's engine, although a great improvement on all that had hitherto been constructed, yet had the great disadvantage of requiring the constant attention of a skilful operator, at a great sacrifice of both time and health, the effect of which was to add considerably to the cost of the instrument. He therefore determined so to arrange the instrument that it might be rendered available without any other means than some moving power; or in other words, he determined to construct a self-acting dividing-engine. This engine has a divided circle of gun-metal 46 inches in diameter, which was cast in one entire piece by Messrs. Maudsley and Field. The centre of the plate is so con-

structed that it can be entered by the axis of the instrument to be divided, whereby the work can be brought down to bear upon the surface of the engine-plate. In the construction of instrument it was formerly necessary either to divide the plate originally, whereby great expense was incurred, or else to remove that portion of the instrument which was intended to receive the divisions from its axis and contiguous parts, in which state alone it could be placed upon the engine. The danger of detaching the divided circle of any instrument from its axis, is that when re-framed there is frequently a very sensible eccentricity; that is to say, the centre of the divided circle is not in the axis of rotation. Error arising from this source may be avoided, when using the instrument, by employing two opposite readings, but in instruments which are provided with only a graduated arc of a circle, such as sextants, any error of eccentricity may become very sensible, notwithstanding the care of the artist; hence a great advantage is gained in the use of this dividing-engine, on account of its obviating the necessity of dismounting the limb to be graduated from the axis to which it is intended to be permanently attached.

This engine-plate, that it may be suitable in all cases, is provided with a small centre-plate, which accurately fits into the engine-plate, and to this small centre-plate are fitted steel arbors of various sizes. The worms on the periphery of the divided plate

were cut by a single rotatory cutter, in place of the screw or hob employed for the divided circles of the former engines; this rotatory cutter was fixed in the framing of the tangent-screw, and as each division was brought to coincide with the wires of a powerful microscope, the cutter was entered, and three revolutions of the engine-plate completed the work.

We now proceed to the consideration of the highest branch of the art of graduation, viz. original graduation—an art which for many ages was practised in the strictest secrecy both by artists and also by men of science.

It has been described as one of the most delicate manipulations with which we are acquainted in the mechanical arts, and its successful execution requires such an exquisite delicacy of touch and extreme accuracy of eye as are rarely possessed by one person, and on this account there are but few who are qualified to excel in this art.

The operation of original graduation is so arduous, that Mr. Simms remarks: "To copy the divisions from a circle of large diameter which had been graduated with extraordinary care, upon work of smaller dimensions, would in general be more satisfactory than original graduation. The latter process consists of several successive steps, in any or all of which a certain amount of error may escape detection. In general, such errors go far to balance one another;

but there will be parts in almost every work where faults of graduation appear which can only arise from an accumulation of minute errors."

The earliest methods of division of which any detailed account is given, are those which were carried into execution by Romer and Hooke. The process employed by Hooke consisted in cutting the edge of the plate to be divided into worms, by means of a tangent-screw, which worms were subsequently employed as divisions, when using the instrument. This method of division was found very liable to inaccuracies, and unworthy of reliance, unless the results obtained by the use of instruments thus graduated were checked by means of independent divisions.

Romer's method consisted in stepping a fixed distance throughout the whole of his arc, the space being so proportioned to the radius of the arc, that it was very nearly equal to one of the smaller divisions required; the total length of the arc was in this case altogether disregarded, as number of divisions on the graduated limb were converted into the corresponding number of degrees and minutes, by referring to a table calculated for the purpose.

Hindley employed an original and highly ingenious method of stepping, which is described in the following letter to Smeaton, on the 14th of November, 1748. He says:

"First choose the largest number you want, and then choose a long plate of thin brass: mine was about one inch in breadth and eight feet in length, which I bent like a hoop for a hogshead, and soldered the ends together, and turned it of equal thickness upon a block of smooth-grained wood upon my great lathe in the air (that is, upon the end of the mandril): one side of the hoop must be rather wider than the other, that it may fit the better to the block, which will be a short piece of a cone of large diameter: when the hoop was turned, I took it off, cut and opened it straight again.

"The next step was to have a piece of steel bent in the form as per margin, which had two small holes bored in it of equal bigness, one to receive a small pin, and the other a drill of equal size. I ground the holes after they were hardened to make them round and smooth.

FIG. 78.

"The chaps formed by this steel plate were as near together as just to let the long plate through. Being open at one end, the chaps so formed would spring a little, and would press the long plate close by setting in the vice.

"Then I put the long plate to a right angle to the length of the steel chaps, and bored one hole through the long plate, into which I put the small pin; then bored through the other hole; and by moving the

steel chaps a hole forward, and putting in the pin in the last hole, I proceeded until I had divided the whole length of the plate.

"The next thing was to make this into a circle again. After the plate was cut off at the end of the intended number, I then proceeded to join the ends, which I did thus: I bored two narrow short brass plates as I did the long one, and put one on the inside and the other on the outside of the hoop, whose ends were brought together; and put two or three turned screw-pins with flat heads and nuts to them into each end, which held them together till I riveted two little plates one on each side of the narrow plate on the outside of the hoop. Then I took out the screws and turned my block down until the hoop would fit close on; and by that means my right line was made into an equal divided circle of what number I pleased.

"The engine-plate was fixed on the face of the block with a steel hole fixed before it to bore through; I had a point that would fall into the holes of the divided hoop; so by cutting shorter, and turning the block less, I got all the numbers on my plate.

"I need not tell you that you get as many prime numbers as you please; nor that the distance of the holes in the steel chaps must be proportioned to the length of the hoop."

Graham was the first to point out the fundamental principle upon which original graduation is based, which consists in the possibility of dividing a line into

two parts accurately, but not into three or five equal parts.

If a line is to be bisected, the points of the beam-compass are set at a distance nearly equal to half the line to be bisected; one point is then placed on one dot, indicating one extremity of the line, and with the other a faint arc is described, and this operation is repeated with the second dot as a centre; the two arcs thus described will either include a small space, or be at a short distance asunder, and this distance may be most accurately bisected by hand with a pointer, the vision being aided by the employment of a powerful magnifying-glass.

Other methods besides the foregoing were also employed, the originators of which were the Duc de Chaulnes, Ramsden, Troughton, and others.

It is not worth while to graduate a scale originally which is less than two feet in diameter. Very great care must be taken that the pivots or journals upon which the wheel is supported, as also the bearings within which the journals work, are sound and accurately fitted both to the wheel and to each other.

For such purposes as wheel-cutting, and some others which do not require that extreme degree of accuracy demanded in the construction of astronomical and mathematical instruments, the following apparatus and process will be found perfectly satisfactory.

Let it be required to cut a click-plate for an oval or eccentric chuck, or a rosette for the rose-engine.

A small dividing plate about six inches in diameter having been previously divided, small countersunk holes are bored at each division.

The dividing-plate is made like a face-plate, and divided on the face or plane surface. To the lathe-bed or poppet-head is attached a small fork, between the prongs of which the end of a spring is retained by an accurately fitting pin or gudgeon, which serves as an axis upon which the spring may be moved.

The other end of the spring is furnished with a conical point, which may be caused to fall into any hole or division on the dividing-plate that may be required.

The cutter (usually rotatory) is to be attached to the slide-rest or lathe-bed, and one indentation cut after each alteration of the dividing-plate.

Sometimes the wheel to be cut is fixed in a graduated apparatus attached to the slide-rest of the lathe, the rotatory cutter being carried between the lathe centres.

CHAPTER VII.

TURNING PARTICULAR FORMS.

Having now made the amateur acquainted with the various manipulations which he will require for the completion of any turned work which he may desire to produce, we think it very desirable to go carefully through all the steps requisite to the construction of various useful and ornamental articles which are formed principally in the lathe.

In the present chapter we shall treat of such articles as require only the ordinary lathe gear for their production, such as chessmen, Chinese balls, lamp-stands, &c., leaving the more highly ornamented work for a subsequent chapter.

We may here observe, by way of general instructions as to preliminaries, that the operator should, before commencing his work, ascertain that he has all the tools and other appliances requisite for the job. He should also see that the lathe-fittings are in good order, properly screwed up and supplied with oil, and

finally repair any damaged tool, and carefully set such as require it upon a good oil-stone.

The work being finished, the operator should carefully wipe all his tools and replace them in their proper drawers, and also remove any chips or grit that may have adhered to the lathe.

By taking these precautions the workman will find that, although a little extra time may be expended upon them, they will, in the end, prove a great saving of time, as he will then always know where to lay his hand upon any of his tools.

We will commence our consideration of the method of turning various forms with those of the most simple construction.

In the first place, let it be required to turn a wooden case for the reception of pencils.

We first select a suitable piece of soft wood, free from cracks and knots, a little longer than the required case. The prong-chuck is then to be attached to the lathe-mandril, and one end of the work being rested against the back poppet, is brought up to its proper position, fixed, and the back-centre screwed firmly into the end of the work.

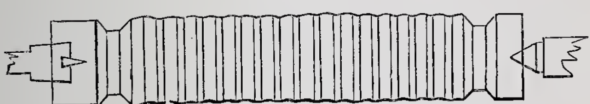
The work may then be set in motion, and means be taken to ascertain whether it has been fixed in the most satisfactory position as regards its central line; if so, the operator may then proceed with the work.

The first process will be the reduction of the material to nearly the form and size of the finished article.

This may be commenced with a gouge, and when the rough edges are removed and the work rendered tolerably circular, it will be found convenient to turn a short piece at each end of the work down to nearly the required diameter, which parts will act as guides in reducing the remainder of the work.

The grooves above mentioned may be conveniently produced with the point-tool or the parting-tool, and the work will then present the appearance shown in the subjoined sketch.

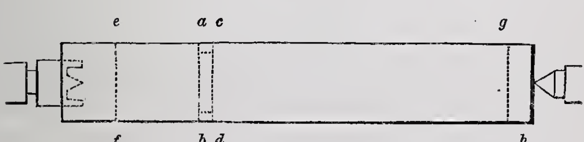
FIG. 79.



The remainder of the superfluous material may now be turned off as far as the grooves with the gouge and point-tool, and the whole length brought to a cylinder a little larger than the required case.

The top and bottom of the case may now be separated, which is to be done in the following manner:

FIG. 80.



Let the accompanying figure represent the work when turned down to a true cylinder. We have now to separate the top and bottom pieces and to fit them together. Make, with a black-lead pencil, the four marks indicated by the dotted lines, *a b*, *c d*, *e f*, and *g h*, and let them be at such distances that *e a* is equal to the length of the top of the case, minus the screw by which it is to be attached to the bottom, *a c*, equal to the length of the screw of attachment, and *c g*, equal to the length of the bottom or box.

The wood may now be cut nearly through, on the line, *g h*, leaving only sufficient material to enable the back centre to support the work. The same process may be also applied at the section *e f*.

Now let a slight shoulder be turned at *a b*, leaving a recess between *a b* and *c d* a little longer than the screw of attachment, and let the work be here turned down to the external diameter of the required screw. The two pieces may then be entirely separated by the parting-tool upon the line *a b*. The two parts may now be proceeded with separately, and we shall commence with the top of the case.

The top of the case is now to be firmly fixed in a cup-chuck and turned out hollow, after which the thread by which it is fitted to the screw on the bottom of the case is to be turned.

The cover may, if necessary, be broached out with a half-round broach, and then be laid aside for a time

that the bottom of the case may undergo processes similar to those applied to the cover.

If the bottom of the case is too long to be supported entirely by the cup-chuck, the free end may be sustained by means of the boring-collar, both while it is undergoing the process of boring and also that of cutting the thread upon the screw.

The two parts of the case being thus bored and fitted, they must now be screwed tightly together, and again fixed between the centres as at first.

Matters being thus disposed, the case is turned down to the dimensions of the finished case.

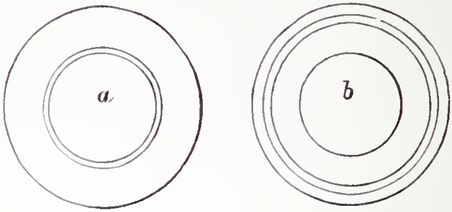
This process having been completed, all that remains to be done is the staining and polishing of the case.

We have, in the above case, purposely selected the most simply constructed article for the first essay of the amateur, beyond those which we have already considered in a former part of the work.

This work having been satisfactorily concluded, the operator may now proceed to some example in which considerable practice in facing may be afforded.

We will now select for our next specimen a circular stand, such as is used to support bronze and other ornaments, which might otherwise injure the piece of furniture upon which it may be stood.

Fig. 81.



The required stand is represented in the annexed fig. 81; *a* shows the bottom, and *b* the top of the stand.

A piece of wood which is tolerably hard and of even grain should be selected for the present purpose, and this being planed flat and true on one side is to be fixed upon the face-plate, as a screw-hole in the centre is not objectionable to the article which we are about to construct.

The work being chucked on the face-plate, the rest is brought close up to its surface, and the T-piece set at a convenient height, namely, on a level with the axis of the article to be turned, the object of which is that the work may move directly towards the edge of the cutting-tool, whereas if the rest were placed higher or lower the material would come to the point of the tool in a diagonal direction.

Things being thus arranged, the great superfluity of ligneous material may be removed with a gouge; this being done, we next come to operate by means of the

point-tool, commencing at the edge and working towards the centre.

The rim of the stand is now roughly cut out by means of the parting-tool. The flat surface may now be completed, and the most suitable tool for effecting this purpose we find to be a broad-edged chisel; but if the edge of the chisel were perfectly square, there would be the danger of the corners of the chisel cutting too deeply and scoring the work, and therefore it is necessary in forming these tools to round off the corner, and in fact to make the whole edge not straight, but of very slight curvature.

The truth of the work must be occasionally tested by means of a straight-edge, and the thickness by inside and outside callipers. This surface being true, such grooves or other ornamentation as is intended to be put on the work, may be cut with a graver or very fine point-tool. All that remains now to be finished is the rim of the stand, the inside of which, being straight, may be wrought with a side-tool, and the outside by means of a point-tool guided by a template.

The work being thus reduced to the required form, it may be smoothed by the application, first of glass-paper of medium fineness, after which very fine glass-paper should be used, and finally a few of its own shavings may be held against it.

The work is now ready for staining and polishing, which may be effected by means explained in the chapter devoted to that subject.

We will now turn our attention to the production of spheres and various spherical works, and we will commence with the method to be used for the turning of a plain sphere.

First bring the material, of which the ball is to be constructed, of dimensions slightly exceeding those of the required sphere. Let the rough work be now fixed in a cup-chuck, and reduce it to the true diameter of the finished article, but with some allowance for polishing, &c., and at the middle of its length mark a ring by means of a fine-pointed lead-pencil, whereby to determine the centre of the sphere while turning its ends.

The ends of the ball are now to be reduced as nearly as possible to semi-spheres, the manipulator being guided in this operation by a wooden or metal template, cut out in the form of semi-circles of the required radius, and having its concave edge rubbed with red chalk, so that when the template is applied to the work, those parts of the latter which are the highest, and which therefore require to be turned down, may be marked by rubbing a portion of the chalk from the template.

Now take the ball from the chuck and replace it at right angles to its former position, then again apply the black-lead pencil, which will mark off the high points, which are of course to be turned down.

The ball is again removed from the chuck, and again chucked at right angles to both its former positions, and the same process, as above stated, must be

repeated. By thus changing the position of the ball several times, the amateur will, after a little practice, be enabled to produce a sphere of tolerable accuracy. Theoretically speaking, chucking the ball in the three positions, each one being at right angles to the two others, and operating upon it while in these positions, should be sufficient for the production of an accurate sphere; it will, however, be found that, unless the manipulator is possessed of a considerable amount of practical skill, the process of obtaining a true sphere will be very materially shortened and facilitated by adopting a greater number of axes upon which to chuck the ball.

The grinding and polishing of spheres is a complicated process, and one which requires some practice and ingenuity. A great number of machines have been designed for the purpose of grinding the ball-valves of locomotive-engines, the object especially sought in such machines being to cause the abrasive material used to act equally on every part of the surface of the sphere, thereby reducing all parts of the work to the same radius, and finishing the article accurately.

A description of these machines would, however, far exceed the limits of the present chapter; we must therefore, though some of them are exceedingly interesting in point of principle and elegant in construction, pass them by without any further notice this work.

We will now inform the student of the steps which

he should take if he desires to turn a cube within a ball.

Having first turned the ball as above directed, mark off the positions of the ends of the three rectangular axes, which will give six points, corresponding to the six sides of the required internal cube; taking these points for centres, holes must now be carefully drilled through each, the depth of which is equal to a little less than the difference between the radius of the ball, and half the length of one edge of the internal cube; the diameter of each hole must be about half the length of one edge of the required cube, the ball being fixed in the cup-chuck with one of these holes exactly concentric with the axis of the lathe-mandril. A right-angled parting-tool is introduced, and the cube cut away from the ball on one side, and its surface finished; this tool is then withdrawn, and the internal surface of this portion of the ball finished with a curved tool, whose cutting-edge is convex, and of the same radius as the inner surface of the sphere.

The other sides of the cube are now in similar manner detached from the sphere, the spaces between the cube and the ball being filled up with some very fusible material previous to the production of the last formed surfaces of the cube; when the whole is complete, heat is applied until the composition is sufficiently soft to allow of its being removed.

The ball and cube will now be complete, and they may be varnished and polished as required.

It may be not uninteresting now to explain the method by which the celebrated Chinese balls are produced. We will suppose that it is required to turn a sphere which is to contain within itself nine other spheres, the surface or every sphere being ornamented by a carved design.

The first step in the production of this curious work of art will be the turning of the outer sphere, which may be done according to the instructions already given.

We must now decide upon the number of apertures which we purpose having ultimately in each sphere. This being known, we commence by drilling holes of very small diameter from the points marked, for the centre of this aperture to the centre of the sphere; which holes are afterwards bored out to a conical form, having at the surface a diameter equal to that of the intended apertures in the external sphere, and terminating at the centre of the sphere.

Fig. 82.

By these holes the means of separating the spheres are provided; but these holes, which are ultimately to remain in the spheres, will be sufficient for this purpose, as it is evident that, for the complete separation of the various shells, the distance between the centres of any three contiguous circles must be such that the parting-tools introduced at each

aperture may be enabled to cut away all the material intervening between these circles.

A sufficient number of conical holes must now be bored to allow of the execution of this process, those holes which are not admissible in the finished article being closed by plugs screwed into them.

The method of proceeding with the separation of the various spheres is as follows:

First, let a side parting-tool be prepared for each sphere of such form that the cutting part is curved on the convex side to a radius equal to that of the internal surface of the sphere within which it is to act; the concave side having the radius of the external surface of that sphere which it is designed to separate from the sphere which envelops it.

All the requisite holes being bored, and the sphere being chucked, the manipulator commences his work by separating that sphere which is of the smallest diameter, or by hollowing it; if it is intended to be hollow. This is accomplished in the following manner; That parting-tool which is the smallest, and therefore that one designed for this part of the work, is inserted within that aperture which is concentric with the lathe-mandril, and being inserted to a proper depth, which may be determined by a stop on the parting-tool, or otherwise, a cut is made with it to the full extent of its reach, whereby the internal sphere is partly separated from the circumjacent material.

This being done, the ball is again chucked with

another hole concentric with the lathe-mandril; the process above mentioned is now repeated, and these manipulations are continued until the internal sphere is free, precautions being taken to retain it in its proper position during the final cut.

The above processes are repeated with every sphere, so that finally the whole nine are severed from the external sphere, and from each other.

All that now remains to be done is the engraving of the intended device or devices upon the surfaces of the sphere, and this is not so difficult of execution as it may, at first sight, appear. The method of producing this final effect, is by bringing the various spheres into such positions as will expose the whole of the surface of each individual shell to the view of the operator at the various holes in the exterior spheres; each part of each sphere as it comes opposite the apertures in those above being carved, so that at length the whole surface being operated upon, the device is complete.

We may now stop up those apertures which were made solely for the purpose of completing the design, and this must be done with great care, and if the designs on the surfaces of the spheres be continuous, this process must be first carried into execution, although much more trouble is incurred thereby.

It may be desirable here to observe that the above is the method whereby the original specimens of these

curious works of art are produced, in order to remove from the mind of the amateur any doubt that may there exist upon this interesting subject, on account of the uncertainty in which the manipulations used for the production of the above articles has for a long period been involved.

A short time since, a scientific gentleman had in his possession some of these works which had been injured in their transit, by which injury the plugs were caused to separate at some parts from the shells into which they were screwed, furnishing unquestionable proof as to the manner in which these articles are produced.

No doubt the amateur will desire to produce from his lathe a set of chessmen, more especially if he personally should take pleasure in that highly scientific and most interesting recreation, chess.

We will therefore take separately a specimen of each kind of piece, and show the method of constructing it, whether in wood or in ivory.

Fig. 83.

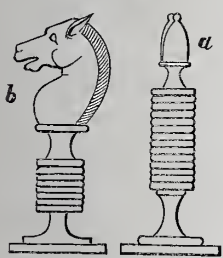
We will commence with the simplest form employed in the formation of these articles, wherefore we select as the object of our study that piece, insignificant in appearance though useful in practice, commonly termed a pawn.

This piece is made in two parts, the head and the base; these should each be roughly reduced

to the required form, and then screwed together and finished while thus united. The ornamental circles on the stem of the piece may conveniently be wrought with moulding tools, and by taking such a step the manipulator will ensure similarity of form in all the pieces of the same name.

The sixteen pawns having been thus produced, we may next, in a similar manner, turn the stands of the knights, and also the bishops, the division in the mitre being subsequently formed.

Fig. 84.

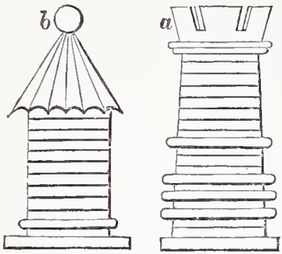


In fig. 84 we have given a representation of these pieces, *a* showing the form of a bishop, and *b* that of a knight. These pieces are in some chess sets made so as to be producible entirely by the lathe, but we think that the forms herein adopted are far more distinctive and satisfactory.

The amateur will very possibly find some difficulty in carving the head of the knight, but a little patience will enable him to effect this without discredit.

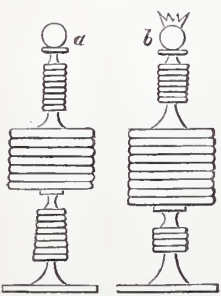
We now pass on to the construction of those more important pieces called rooks, or castles, of which we have represented, in the subjoined cut, two forms.

FIG. 85.



The form of castle depicted at *a* is somewhat unsightly, but it yet has the advantage of being more easily formed than that at *b*, which latter however, amply repays by its pleasing appearance the extra labour and time expended upon it. These objects may be turned either in the cup-chuck or between the centres, but the former will be found most satisfactory, on account of its allowing the manipulator to get at the various parts of the work with greater facility than the method in which the last-named instruments are employed. The minor details of the manipulations necessary to the production of these pieces, are so similar to those of the processes adopted in the construction of articles of the same dimensions which have already been described, that an account of them would be a work of supererogation.

FIG. 86.



In the accompanying sketch are represented the last pieces of which we shall treat. *a* shows the form of the queen, while *b* gives that of the king; the only difference between the pieces consisting in the crown on the head of the latter; they are each of them made in four

pieces, namely, the head, the body, the stem, and the foot. They may all be readily turned according to the methods adopted in the foregoing chapters. They are united by means of solid screws cut on the ends of the stems, or smaller pieces which fit into internal screws cut in apertures in the parts which are of larger diameter.

The forms which we have selected for the above set of chessmen are of the simplest, on account of these being entirely, or almost entirely, produced by the lathe alone.

A very elegant, and at the same time useful article, may be turned in shell in the following manner.

Fig. 87.

The accompanying figure represents a stand for rings, or other similar articles, and will form a pretty appendage to the toilet-table. It consists of a cup or tray, *a*, to the bottom of which is attached a small ivory stem, *b*, either by a screw or by other suitable means, and to this is attached a small foot, *c*, which, like the tray, is formed in shell.

A suitable shell being selected for the construction of the upper part of this ornament, all that is requisite will be to remove its rough surface, polish it, smooth off the edges, and prepare a place for the reception of the stem, *b*.

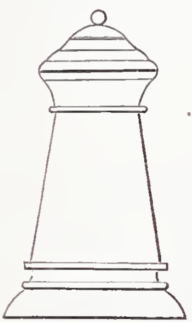
The stem, which is of ivory, may be most conveniently turned in a cup-chuck, and the production

of this will be the least troublesome part of the work.

The foot, which is, like the tray, formed of a nacreous shell, will require only the same preparation as that part of the article.

Devices may, if such are desired, be carved, drilled, or otherwise produced on the various parts of the work; but the method of accomplishing the manipulations required in the execution of these designs, belongs more properly to the subject of ornamental turning than to that of which we are at present treating, we shall, therefore, postpone the consideration of that portion of our work for the present.

Fig. 88.



We will now turn our attention to the construction of a small case for matches, such as that represented in the accompanying figure. It will be found most convenient to form this work in three parts, namely, the lid, the centre part, and the bottom, and these will be attached to each other by screws cut on the corresponding parts. The central part may be most economically produced by selecting a portion of material the centre of which is hollow or unsound; but if the amateur should not be possessed of such a piece, he may economise the work as far as possible by cutting out the core with a very thin parting-tool.

The bottom and the top of the case may be formed in the ordinary manner, the top being provided with a boss at its summit, in which is bored a small cylindrical recess for the purpose of supporting the ignited match. The solid screws should be cut upon the extremities with suitable screw-tools, the internal screws being formed in the central part of the box.

A very delicate and pleasing ornament may be formed in ivory in the following manner: The proposed article is in form similar to a drinking-cup, being slightly conical, and it may be used for the same purpose as our foregoing example, its principal beauty consisting in its great delicacy.

A piece of ivory, which is hollow, or otherwise suited for the required purpose, having been selected, it is bored out to the intended internal dimensions, this part being made separate from the bottom. The outside of the work may also be turned to nearly the required size. The work is then removed from the lathe, and a sufficient number of coatings of the composition intended for this purpose, and for which we have given a recipe at p. 233, placed evenly on the internal surface to afford sufficient strength to the work during the subsequent operations. It may then be placed on the spring arbor-chuck, and there reduced to the desired dimensions, the darkness of the composition with which the internal surface of the work is lined showing through the material, and providing a means of estimating its thickness. The external

surface of the work being completed, a small groove must be turned on the inside of one end of the tube thus produced for the reception of the bottom of the stand, and the edge of the other end may be chamfered down. The article is now removed from the lathe, and the composition removed from its interior by the means prescribed for that purpose. The bottom of the stand may now be turned of any material which the amateur may require, such as tortoiseshell, which, being required to be turned very thin, may most conveniently be formed upon the cement-chuck. Its edges must be chamfered off to fit the groove within the foregoing part of the work, and it should be turned of such a diameter as to fit tightly when in its place, into which it may be introduced by previously warming the exterior part of the article, whereby it will be sufficiently expanded to admit of the introduction of the disc forming the bottom, which it will firmly clasp by the contraction produced on cooling.

The work may be ornamented and protected by being gilded at the upper and lower edges. This article may also be used as a receptacle for cigar ashes, but in this case it will be found desirable to line the work.

We will now describe a process which, though simple, may be unknown to our readers. We refer to the formation of tortoiseshell setting to eye-glasses and lens-holders.

Select a narrow slip of tortoiseshell, whose width is something more than twice the width of the rim of the setting, and in this cut a slot, the length of which is one and a half times the diameter of the glass which it is destined to contain. A similar aperture is also formed bearing the same proportion to the intended diameter of the ring which is to form the handle. The strip must now be softened by heat, the slots pulled open and brought to the required shape by a taper triblet. It may then be turned, and subsequently re-heated to allow of the insertion of the lens.

Having already, in a former part of this treatise, detailed the construction of some curious apparatus intended for the production of the most delicate and fragile works which may be manipulated by means of the lathe, namely, those elegant little vases which are formed from various egg-shells, which process is the ingenious invention of Mr. G. D. Kittoe, and it is one which he has found successful for the working even of such delicate material as the sparrow's egg-shell, but in this, and all other similar cases, the utmost steadiness of hand and delicacy of manipulation which are available, must be had recourse to.

We will now suppose the amateur is desirous of producing a small ornamental vase from an ordinary egg, the top and bottom pieces, as also the fittings, being made of ivory.

The egg is thus fixed in the paper spring-chuck,

described in our chapter on Miscellaneous Apparatus; The chuck being attached to the lathe-mandril, its internal surface having been previously rubbed with diachylon or other adhesive substances, the egg is carefully placed in it, the latter being kept revolving at a very slow speed with one hand, while the egg is adjusted with the other, until he observes that it runs perfectly true. He must then, with a sharp-pointed tool, accurately mark the centre of the egg-shell, and drill a hole sufficiently large to allow the wire in the chuck, subsequently used, to pass freely through it.

This being done, the egg must be taken from the chuck, reversed, and the same operation performed at the other end; it is then removed from the chuck, and emptied of its contents by blowing carefully through it; it will now be ready for cutting, for which purpose it must be fixed in the chuck formed for this special operation, and which may be called a wire-chuck, or double cup-chuck. In attaching it to this chuck it must be carefully slid on to the wire, placed against the fixed end of the chuck, and the small cup or chuck placed close against the end opposite to that which rests against the largest part of the apparatus, and there retained by the nut upon the end of the wire; this must be screwed up sufficiently tight to retain the work in position whilst it is being divided, but care must be taken that it be not screwed up too far, for, although the egg-shell

while whole exercises a comparatively great amount of resistance to crushing force, it will, when severed, split under slight pressure, especially if the cut edges be brought into contact.

The top and bottom ivory ornaments may now be turned; they are attached to the shell by means of fine ivory screws, the heads of which are placed within the shell.

The rings also which form the fittings must now be carefully prepared and attached to the edges of the shell, but this is a process requiring considerable care and delicacy of manipulation, as without such the edges are very liable to become chipped.

The foregoing is, perhaps, one of the most elegant, and certainly the most delicate, of the manifold specimens of manipulative excellence.

Having provided the amateur with detailed instructions whereby he may be enabled to construct a considerable variety of useful and ornamental works, the production of which will afford him a sufficient amount of experience to impart that confidence which is requisite to the satisfactory execution of any work which may be desired which does not require the application of the ornamental chucks, we shall take leave of the present subject.

CHAPTER VIII.

ON STAINING, POLISHING, ETC.

The amateur will no doubt be desirous of rendering some of those articles which he has turned from materials which do not themselves exhibit any pleasing tint, more satisfactory in this respect by means of some artificial colouring. To meet the requirements of the operator fully, and at the same time to avoid incumbering our space with a large amount of comparatively useless matter, we have selected such recipes from our own experience, and also from that of others, as have been proved capable of fulfilling all that may be required of them, by way of convenience, of application, brilliancy, and durability.

The manner of applying the substances for which we are about to furnish the recipes, will of course vary with the nature of the materials used; but a few general instructions may, nevertheless, be acceptable in this place.

The application of stains is not a process of any

difficulty as a rule, all that is necessary being a proper distribution of the colour, so that the object which is thus operated upon may not be of a darker tint upon any part of its surface than upon the remainder, as any appearance of patchiness will altogether destroy the pleasing effect which is the object of the process.

In laying varnishes on any surface, greater care will be required, and particular attention must be paid to the state of the brush; thus, it should never be so full of varnish as to allow it to drop, nor should it be worked to dryness.

In all cases it must be borne in mind that no second or other coating of varnish or colouring matter should be applied to any surface until the coating previously laid on has become perfectly dry, otherwise the finished surface will not present a uniform appearance.

In using any kind of glue or cement to join two or more pieces of any material permanently, no more of the adhesive material should be suffered to remain in the joint than is absolutely necessary, as otherwise a sound junction of the component parts of the work cannot possibly be obtained.

When two pieces of any material are to be joined together by means of glue, the following method of procedure should be adopted.

The parts of the joints be made to fit each other accurately, should be wiped perfectly clean and free from grit; they should then be warmed, and the glue applied in a thin stratum to each piece. The two

pieces are now to be put into position, moved about slightly upon each other, at the same time applying a moderate amount of pressure, until they set together, when they may be laid aside to cool, first having carefully removed by means of a damp cloth the glue which has exuded at the edges of the joint.

The same means as above stated should, with the exception of warming the pieces, be applied to joints in all cases where the cement used is of a glutinous nature. The pieces should be warmed only when the cementing mixture is used hot.

Those cements whose liquefaction and solidification depend entirely upon the application of heat or water, or both, usually take a considerable time to harden, and are of course liable to be again softened by the occurrence of the presence of heat or contact of water, whereas those cements which harden on account of the chemical combination of their elements, usually set quickly, and also, being once solidified, are incapable of being again softened and liquefied by any of those causes to which they may be subject.

We may here observe that the lime cement is one of the most valuable with which we are acquainted, not only on account of the great variety of purposes to which it is applicable, but also by reason of the rapidity with which it sets—viz. about fifteen minutes—and also its great tenacity and durability, and its incapability being again resolved by any ordinary cause into its component parts.

It may be desirable to mention the test to which we have subjected the capabilities of this cement.

Having carefully gauged a portion of this cement, according to the instructions of the following pages, a thin glass cylinder recently fractured was reunited with due regard to the precautions above detailed.

The cylinder having been allowed to rest for about half an hour, was exposed for an equal time to the action of a lárge clear coal fire, after which its strength remained unimpaired. It was then boiled in water for half an hour, after which it was only fractured by the exertion of considerable force.

Another experiment on the properties of this cement was attended with the following satisfactory result. Two strips of crown glass, each about a quarter of an inch in width, were accurately united on their polished faces along about half an inch of their length.

The glass beam thus constructed having been allowed a sufficient period for the cement to set, it was supported at the ends, and repeatedly fractured by a transverse strain; in every instance the solid glass gave way, until it was broken away, so as to leave only the joint remaining, which was then split after a few smart strokes from a hand hammer.

With regard to the great range of materials to which this cement may be applied with advantage, we may instance the following: Wood to wood, wood to cast iron, wood to brass, cork to brass, wash leather to cork, glass to glass, ivory to ivory, and innume-

rable others the notation of which would occupy more of our space than we can conveniently afford to a subject of so little comparative importance.

We will now proceed to the immediate consideration of the recipes which this chapter is destined to contain, and we shall commence with those materials which are suitable to the staining of wood in order to imitate woods of superior value or tint.

Purple Stain.

Take of logwood one ounce, of Brazil wood a quarter of an ounce, and of water one quart. The maceration of these materials being completed, it may be applied to the work to be stained, after which, the surface of the latter may be brushed over with a solution of a quarter of an ounce of pearl-ash, dissolved in one quart of water.

This produces a very beautiful and exceedingly durable stain, without causing that unnatural appearance which results from the use of stains of an inferior character.

Black Stain.

Having obtained some of the best logwood shavings that can be procured, place them in a jar or other equally convenient utensil, pour upon them a sufficient quantity of boiling water to completely cover them, and place the jar in a warm situation until the water has exhausted the logwood, or is saturated with the

extract; in the former case it will be necessary to re-heat the extract of logwood, and pour it over some fresh shavings of that dye-wood, and this process must be repeated until the water be completely saturated.

When this mixture is required for use, it must be boiled and applied while hot to the work to be stained, after which it must be brushed over with common ink.

It may be as well to provide the amateur with a recipe capable of producing good ink.

Take of Aleppo galls, finely bruised, six ounces; crystallised sulphate of iron, of the best quality, four ounces; gum arabic, four ounces; and of water, six pints. Boil the galls in water for about the space of two hours, occasionally adding water to supply the loss resulting from evaporation: then add the other ingredients, and keep the whole for two months in a glass vessel, which must frequently be shaken. Finally, strain the ink into glass bottles, not forgetting to add a few drops of kreosote, in order to prevent it from becoming mouldy.

When the ink has not been kept for a sufficient length of time, and is pale in writing, it becomes black in consequence of the oxygen of the air converting the protogallate and prototannate of iron into pergallate and pertannate; but when the writing becomes yellow and indistinct from age, it is from the decay of the vegetable portion of the ink, little more than the peroxide of iron being left on the paper.

Red Stain.

A very convenient red stain may be produced by the decoction of the following materials: Brazil-wood, two ounces; potash, two ounces; and water, one quart. This should be applied while hot, after which a solution of alum should be brushed over it, the proportion of which should be two ounces of alum to one quart of water.

Light Mahogany Stain.

Let two ounces of madder and one ounce of fustic be mingled with one quart of water, and the whole boiled until the concoction be completed. This having been applied to the work, it must subsequently be washed with a weak solution of potash.

Dark Mahogany Stain.

For the imitation of the more valuable kinds of mahogany, a stain somewhat darker than the foregoing will be found necessary, and as the Honduras mahogany and similar woods are more valuable and more beautiful than the lighter material, it will be more frequently found desirable to make use of the following recipe:

Take of logwood, half an ounce; of fustic, one ounce; and of water, one quart. Let these be boiled together for a sufficient period, and when cold, apply it to the work to be stained, after which it must be

washed with a weak solution of potash, as mentioned in the foregoing receipt.

Yellow Stain.

Although yellow is not among the colours most generally in favour for the colouring of wood, and the stains scarcely admit of being applied partially on account of the rapidity with which they are absorbed by the soft woods, whereby more pleasing results may be produced, we yet deem it desirable not to omit this colour from our catalogue of recipes, whereby the latter would be rendered incomplete.

For the production of the yellow stain, take turmeric, one ounce, and of spirits of wine, one pint, and allow it to stand until the former be extracted, when the tint will be ready for immediate use.

Having now given recipes for those colours which the amateur will be most likely to require, we will offer a few observations on the finishing of articles constructed in wood.

There are two methods of finishing work, namely, by varnishing and by polishing; by the first, a solution of gum or gums, insoluble in water, is spread over the surface to be finished with a soft brush, and allowed to dry; should a second coating be considered necessary, it must not be applied until the first is quite set.

Before varnishing, it is requisite to reduce the surface of the work to as smooth a condition as possible,

and care must be taken that the room in which the work is to be varnished be warm and free from moisture, as water would precipitate the gums, thereby rendering the varnish cloudy.

The varnish should be applied more sparingly at the edges than at the other parts, and the strokes of the brush should be as few as possible, and always in the same direction.

If the surfaee of the work is very porous, a eoat of size should be laid over it previous to its being varnished.

We now proceed to the method of finishing work by polishing.

In French polishing a brush is not used, but in its place a rubber, consisting of a few folds of cloth or linen rag, is substituted. It is thus applied: The rubber is moistened with the polish, and a fold of thin rag is placed over it; on this is poured a few drops of oil, and the whole is applied evenly on the surface of the work, never allowing it to remain long in one place; this operation being repeated whenever the rubber becomes dry.

We will now proceed to furnish the operator with a few recipes applicable to the foregoing purposes.

Best White Hard Spirit Varnish.

Take the best picked gum sandarae, a quarter of a pound; of spirits of wine, one pint; mix, and agitate without intermission until the gum is dissolved,

than add two ounces of Venice turpentine, warmed sufficiently to make it fluid.

Or—Take of gum sandarac, seven ounces; of spirits of wine, one pint; of turpentine, the eighth of a pint; or, in other words, two ounces and a half; mix, &c.

Or—Take of gum sandarac, four ounces; gum mastic, two ounces; spirits of wine, one pint; and mix.

Brown Hard Spirit Varnish.

Take of shellac, four ounces; of spirits of wine, one pint; Venice turpentine, two ounces.

Or—Take of shellac, four ounces; sandarac, two ounces; mastic, a quarter of an ounce; spirits of wine, one pint.

Or—Take of shellac, two ounces; sandarac, four ounces; spirits of wine, one pint; turpentine, an eighth of a pint.

The following recipe will produce good useful varnish for common purposes.

Black Spirit Varnish..

Take of shellac, four ounces; of methylated spirits of wine, one pint; of vegetable black (not lamp-black), sufficient to render the whole black.

Hardwood Lacker.

Shellac, four ounces; spirits of wine, a pint.

Or—Seedlac, two ounces; white rosin, two ounces; spirits of wine, a pint.

French Polish.

Take of picked shellac, three ounces; spirits of wine, one pint; dissolve these without heat Copal, sandarac, mastic, and gum arabic are sometimes added in various proportions, principally for the sake of obtaining a lighter colour, thus:

Take of shellac, two ounces; of gum arabic, one ounce; of copal, half an ounce; spirits of wine, one pint and a half. Or, when a darker colour is required, take of shellac, two ounces; of gum benzion one ounce; of spirits of wine, one pint. If it is desired to colour the polishes, this may be done by the addition of dragon's blood.

We will now give recipes for adhesive substances.

Glue.

In preparing glue, the proportions adopted should be a pound of glue to one quart of water. The glue should be soaked for some time, say twenty-four hours, in cold water, previous to dissolving it. The glue may then be dissolved by heat; but the vessel in which this is accomplished should be surrounded with water, in order to prevent it from attaining a greater heat than the boiling point of that liquid, whereby it would become burnt, and its adhesive properties destroyed.

A tolerably good soluble glue may be made by dissolving the ordinary glue in an excess of water, straining through muslin, adding sugar, and evaporating down to a thick consistency, when the glue thus produced may be poured into moulds to harden.

The following is a good cement for glass, ivory, &c. When cold it is hard, but may be softened by placing the bottle in which it is contained before the fire, or in warm water:

Take of spirits of wine any desired quantity, and add thereto as much of the best isinglass as will saturate the spirit: then dissolve in a warm place.

General Cement.

Take of good moist cheese any convenient quantity, place in a saucer, and pour thereon boiling water, working it with a knife so as to expose it thoroughly to the action of the water; as soon as this latter becomes turbid, pour it off, and add more; repeat this process until nothing remains to be washed away; the residue of the cheese will now have assumed a waxy consistency, which will be indicated by its allowing of being drawn out into long filaments; when this is the case, about half its bulk of quick lime should be added, and the whole well kneaded together with a knife or spatula; it must be used immediately, as it sets in about fifteen minutes.

This cement may be made to keep by drying the waxy substance, pulverising it, and mixing therewith the proper proportion of lime; it should be kept in an air-tight bottle. When required for use, it must be kneaded into a paste with a little water. This method is not so satisfactory as the first, as the ingredients of the compound are liable to deterioration by exposure.

Turner's Cement.

Take of Burgundy pitch, two pounds; of rosin, two pounds; of yellow wax, two ounces; and a ball of whiting. Place all, with the exception of the latter, in a pot over a slow fire; as it begins to melt, stir it with a stick to prevent it from bubbling over; when melted, take it off the fire, gradually add the pulverised whiting, and endeavour to incorporate it thoroughly. In this it is very improbable that the amateur will at first be successful, therefore he may pour the mixture from a small height into cold water, whereby it will be granulated, then grind the whole to a powder and remelt it, when it will be found to be thoroughly mixed; it may now be moulded into balls or sticks.

When required for use, hold the ball or stick against the cement-chuck while the latter is revolving; the heat generated by the friction will be sufficient to melt the cement.

Composition used in turning Ivory very thin.

Take some ivory or lamp black, perfectly free from grit, and mix it with a sufficient quantity of hot glue to reduce the whole to the consistency of thick oil paint. Apply this by means of a brush to the inside of the work, which is, of course, previously finished, and when one coat is dry lay on another, until sufficient strength is obtained. The work may now be finished on the outside, the colour that shows through the work being a tolerable indication of its thickness.

The composition may be removed by placing the article in warm water for a few minutes; it will then soften, and can be rubbed of with facility.

The ivory should be washed in two or three waters, to prevent its being stained with the black.

We will now turn to the consideration of those matters which are intended for the production of stained surfaces on ivory, such being frequently required for draughtsmen, chessmen, billiard-balls, &c.

Red Stain.

Boil together half a pound of scraps of scarlet cloth, with one ounce of soft soap, in three quarts of water; stir and press to extract the colour, strain the liquor, and add thereto a small quantity of alum.

When this is required for use, steep the article to be stained until it becomes a proper colour.

Black Stain.

Take a quarter of a pound of logwood, and extract it by boiling in a quart of water, and steep the ivory to be stained in the solution thus obtained.

When ivory is being stained by immersion in hot liquors, it should, immediately on removal from the liquor, be plunged into cold water, otherwise it is liable to be cracked.

Having now concluded our recipes for stains and varnishes, we will give a few instructions of a similar nature with regard to the working of tortoiseshell, &c.

To join Tortoiseshell.

File down the ends to be joined to the condition of feather-edges, taking care that no grease is on the surface; then bring them to the proper position, and bind them with clean wet linen cloth. Heat is now to be applied, by means of two flat pieces of heated metal, or by a pair of heated tongs, and continue the pressure until the work has become cold, when, if the operation has been properly carried into execution, the two pieces of tortoiseshell will be found perfectly united.

To imitate Tortoiseshell.

Boil three ounces of potash in a pint of water, and let this be poured upon half a pound of quick lime, and stirred until the lime is slaked; then add two ounces of vermilion, or one ounce of vermilion and one ounce of red lead.

When the mixture has obtained the consistency of cream, with a brush or pointed stick, on a clear piece of horn, trace the required figure, leaving those parts which are intended to be transparent untouched. When dry, the article must be cleaned with a wet sponge, or rag, after which it may be polished with a mixture of chalk and water.

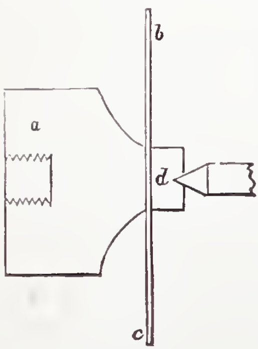
CHAPTER IX.

ON SPINNING METAL.

There are many objects capable of being formed in the lathe which could not conveniently be turned and bored, according to the ordinary methods, but which are amongst the most elegant and useful of our domestic utensils; nor are they confined to one class of articles.

We may include teapots, the mouths of musical instruments, pewter dishes, and other similar articles formed from thin sheets of more or less ductile materials.

Fig. 89.

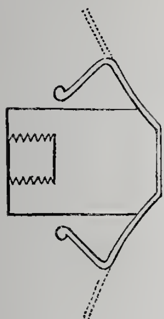


The process to which we refer is termed spinning, and the material is operated upon in the form of a flat disc.

We will now select a few specimens of this useful art, in order to explain the manner in which the manipulations are to be conducted. Let us, for this purpose, suppose that the body of a teapot is the article required.

It will first be necessary to turn a chuck or mould in hard wood to the form designed for the bottom of the teapot. This chuck is then screwed on to the lathe-mandril as shown at *a*, fig. 89. *b c*, in the same figure, represents the disc of metal from which the teapot is to be constructed; it is held against the chuck by means of the block *d*, which is firmly pressed against it by the back centre of the lathe.

Fig. 90.



The lathe being now set in motion, a burnisher is gently pressed against that part of the disc where the first change of form is required. A piece of wood, having a pin attached to the rest by way of a fulcrum, is held on the other side of the disc in order to counteract any sudden pressure of the burnisher, and also to prevent the plate from buckling.

The process having been proceeded with until the disc is wrought to the form represented by dotted lines in fig. 90, the original chuck is removed, and its place supplied by one of smaller dimensions; a hooked tool takes the place of the piece of wood formerly held at the back of the disc, in order to allow of its being brought to the required form. It is desirable to turn a small ring at the edge of the work, which imparts to the object both finish and stability.

In place of the small block and hooked tool which

we have just now mentioned, a chuck of the exact form of the interior might be used, but it must be constructed of pieces, in order to allow of its removal from the finished work, and these pieces may be kept in position by a central mandril, on the removal of which the component parts of the chuck may be removed with facility from the finished work.

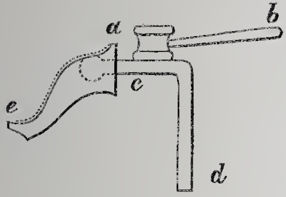
The lid of the teapot may then be spun in a similar manner, and also a ring to be attached to the teapot for a stand; but if this ring should be considered not sufficiently strong, a ring may be cast in the same material, and turned up to a polished surface in the ordinary manner.

We think it desirable to provide the amateur with such instructions as may enable him to complete the work thus begun, although it may appear that the manipulations about to be described are foreign to the purposes of the present work, but we hope that the great interest which cannot fail to be excited by a consideration of that elegant process termed snarling up, will fully repay the operator for the time and labour expended upon the practice of this art.

We will suppose that the spout to the teapot is required to be of the ordinary fluted form, the general contour, with the exception of the flutes, may be produced by inserting moulds or stakes of the proper form within a tube of ductile metal, and bringing it to a condition nearly approaching that of the finished article by means of blows from a light

hammer, after which it will be ready to undergo the above-mentioned process.

Fig. 91.



Let *e*, fig. 91, represent the teapot spout on which the flutes are to be produced, it may be held in the left hand in the position shown in the accompanying figure; the part to be operated upon being rested upon the end of the curved stake *c*, which is firmly fixed by its lower end in the vice or other suitable apparatus.

The operator now proceeds, after having carefully adjusted the work upon the stake, to strike the latter with a light hammer, *a b*, as shown when the end of the stake, having yielded to the blow, will spring back, and strike the work a sharp blow, which process is termed snarling up.

The flutes are completed by carrying this operation along the whole length of the spout.

We may here observe, that by means of the manipulation just described, an almost endless variety of articles, both useful and ornamental, may be produced, and to some of these we shall hereinafter have occasion to refer.

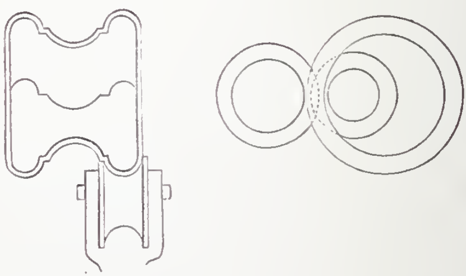
The handle of the teapot being similarly wrought to the required form, and a knob provided for the, lid, as also hinges, all that now remains to be accom-

plished for the completion of the article in hand, consists in the drilling of the strainer, and the soldering together of the various component parts of the work.

The strainer is formed by drilling the surface of the teapot, at that part over which the spout is to be attached, numerous small holes, when the teapot may be soldered together in the ordinary manner, and polished with crocus, putty, or other polishing powder.

Any work of circular section and ordinary form may be produced by the process of spinning. The second example which we will select is a tobacco-box stand, and in this case we shall start, not with a disc of metal, but with a ring or tube of that material:

Fig. 92.



A tube is selected of a suitable size and thickness of the material of which it is proposed to construct the case. The process adapted for the formation of this article may be said to resemble to some consider-

able degree that of stamping or forming work by means of dies, a mandril being used within the tobacco-case which represents one die, while a milling-tool applied to the external surface of the work acts as the other die; this latter taking the place of the movable die or punch, while the mandril supplies that of the matrix or bed-punch.

The method of manipulating the work, of which a section is shown in the above figure, is sufficiently obvious; the mandril must evidently be of less diameter at its greatest section than the interior of the work is at its least section.

The bottom of the stand, which may be soldered on to the part already formed, may consist of a plain metal disc of proper diameter; and the top may be spun from a disc of metal according to the method already described in the consideration of our first example.

While on the subject of works raised upon thin metal, we deem it not undesirable to advance a step further and consider the manipulations involved in the construction of raised works generally, whether they can be produced either by means of, or without the lathe.

We may commence the section with a few general instructions with regard to the process of reducing plates to a truly plane surface, or, in other words, we may explain the method of setting plates.

The irregularities in the form of thin plates may

be considered to arise from three causes; namely, first, buckling produced by an unequal shrinkage of the plate, caused by its leaving the rolls or hammer at a temperature which is not uniform throughout its mass; secondly, buckling produced by an accidental blow; and thirdly, bending and winding, also produced by the same cause; a plate of metal being said to be in winding when it is curved in a diagonal direction or spirally.

There are two kinds of blows to which sheet metals may be subjected, which, although capable of very similar results, act in different manners. These blows are termed hollow and solid blows, the first being such as those which are given when the material is beaten into a mould or hollow, the effect of these blows being to bend the metal, and the latter being such as those to which metals may be subjected when laid upon an anvil-stake, or other convenient support, and which tends to thin out the metal.

If, then, we have a plate of metal which is rendered untrue by buckles on its surface, these must be removed in the following manner: The sheet of metal being laid upon the anvil, it is beaten round the buckle, from the buckle to the edge of the plate, until the whole of the material is thinned out in such a manner as to remove the unequal tension which produced the buckle.

If the plates should be very irregular on account

of a great number of buckles, it will be necessary to hammer it carefully at every part, except those which are buckled; this will require a considerable amount of care and practice, and it may be necessary to anneal the metal by heating and cooling it slowly, in order to avoid the inconvenience caused by its becoming hard under the action of the hammer.

The finest specimen of raised work of modern date is the ball of St. Paul's Cathedral; this ball was raised in two hemi-spheres, which were subsequently riveted together, the line of rivets being concealed by an ornamental band.

The metal for the ball was first thinned, and partly formed under the till-hammer at the copper works, and then sunk in a hollow bed; the raising was effected with hammers not much larger than those ordinarily used. Most of the work of the cross and ball is hammered up; the ball is six feet in diameter, and the whole structure is twenty-nine feet high, and the weight of copper consumed in its manufacture three tons and a quarter.

The metal disc of which any raised work is to be formed, must be so selected with regard to size and thickness that it shall exactly suffice for the production of the article, so as to leave neither excess of metal to remove, nor deficiency to supply; and the blows of the hammer must be so managed, with regard to direction and intensity, that the finished work may be left of uniform thickness throughout.

We will take as an example, by means of which to illustrate the manipulations involved in the production of works raised by the hammer, the construction by this method of a copper ball six inches in diameter.

Two circular discs of copper will be required, the diameter of each of which must be seven inches and a half, one for each hemi-sphere.

The circumference of each disc measures twenty-two inches, and this will be reduced to about eighteen inches, and the diameter of the disc, which is seven inches and a half, will be expanded to about nine inches.

Each hemi-sphere may be raised first by blows from a light hammer, and the form completed in a hemi-spherical mould; if the work is required to present a uniform appearance, it may be found desirable to finish it by hammering it lightly and equally all over its extensive surface, it being rested during this operation upon a stake, the surface of which is spherical.

It will be found necessary during this operation occasionally to anneal the work by the process of heating and cooling slowly, otherwise the desired article will become hard and brittle.

Works may also be raised by the application of dies, but the form and use of these instruments admit of many variations, which would render a full and satisfactory consideration of them a matter demanding more of our space and attention than can be

devoted to a process of, to the amateur, secondary consideration, whilst there are others which he will require to put into actual practice demanding our attention.

Those forms which we have already described in the present chapter will, we doubt not, be sufficient to enable the amateur to obtain sufficient practice in the art of raising metals to become tolerably expert, and his own ingenuity will suggest to him expedients by which to overcome any difficulties which may arise during the progress of the work.

CHAPTER X.

ON MATERIALS.

Having now initiated the amateur in the art of turning both plain and ornamental devices, we think it desirable to afford him such information with regard to the general properties of those materials with which he will have to work. These materials may be thus classed: First: those materials which, from being most soft, are best adapted for the production of toys and similar turned articles; of these we may instance alder, beech, birch, sallow, and willow.

The second class of which we purpose treating is somewhat harder, and capable of being wrought to polished surfaces; these are holly, horse-chesnut, sycamore, apple, pear, and plum-tree; these woods are chiefly used for those articles known as Tunbridge-ware.

The third class consists of wood too hard for either of the foregoing purposes; they are therefore used for such articles as occasional tables, screens, and

other objects of ornament rather than use. The English woods in this class are included in beech, box, elm, oak, and walnut; and the foreign woods in amboyna, beef-wood, ebony, box-wood, Brazil-wood, brazilletto, bullet-wood, cocoa-wood, coromandel, green ebony, green heart, grenadillo, iron-wood, king-wood, lignum-vitæ, locust, mahogany, maple, mustaiba, olive-tree and root, patridge-wood, Peruvian, prince's-wood, purple-wood, red sanders, rosetta, rose-wood, sandal-wood, satin-wood, snake-wood, tulip-wood, yacca-wood, zebra-wood, and cam-wood.

Some of these woods are frequently very scarce, and many of them generally rare. They may be subdivided into three classes. First: black beef-wood, box-wood, bullet-wood, cam-wood, and cocoa-wood. In grain they are generally close; they are possessed of a considerable degree of hardness, are even tinted, and peculiarly adapted to the requirements of those articles which are produced by the oval, eccentric, and other ornamental chucks.

The second class contains black ebony, green ebony, grenadillo, lignum-vitæ, locust, mahogany, rose-wood and satin-wood, which are generally abundant and extensively used for the better class of furniture.

In the third class we may include all those woods not mentioned in the first or second: these materials are used for a great variety of purposes.

The black beef-wood, bullet-wood, king-wood,

snake-wood, and tulip-wood, are frequently extremely scarce, and are therefore used for small ornamental articles.

Although these woods are generally used for ornamental turning, they may also be applied with advantage to the purposes of plain turning.

We may now give some general instructions to the amateur with regard to the selection of materials suitable to any object which he may be desirous of manufacturing, and also with regard to the various speeds at which these materials should be wrought.

We will first consider the various articles which the amateur may at first conveniently produce. These we will discuss under three heads.

The first includes those articles which furnish the amateur with his first lessons in pain turning, such as the handles of tools, toy skittles, draughtsmen, &c.

For these objects a tolerably soft wood should be selected, but it must be borne in mind that in using these soft materials a great velocity is required, and the tools must be very keen, and so constructed that the facets forming their cutting edges should contain an angle not exceeding 30 deg.

Even after having taken these precautions the operator will experience some difficulty in obtaining smooth surfaces when turning cylinders composed of very soft or very fibrous materials.

For this work it is essential to success that the turning-tool is held tangentially to the work which is undergoing manipulation.

When the amateur has perfected himself in the art of turning soft woods, he may undertake the construction of those articles which are formed from harder materials.

These articles are such as the following: Plain ebony snuff-boxes, stands, door-handles, ivory draughtsmen and chessmen, billiard and bagatelle balls, &c., and also the celebrated Chinese balls.

For this class of work the tools require an edge the facets of which include an angle varying from 70 to 90 deg., according to the hardness of the materials.

The tools should be held in a radial position to the work to be turned, or, in other words, at right angles to the tangent to the cylinder which is being turned, and the motion of the work must be considerably slower than that for the soft materials.

For this class of work a much greater variety of tools will be required than for any other, and some of them will be of a form the production of which will tax the skill of the student; of these we may instance the moulding-tools used for the production of ivory chessmen and other similar articles, also the curved side parting-tool, which must be specially manufactured for the construction of the Chinese balls, and of which a considerable number will be required; thus, if the outer ball contains nine others, nine parting-

tools will be required, each one curved to the radius of one particular ball in the series.

The third head includes all those exquisite manufactures for which the hardest and most beautiful woods are employed, and in this practice great opportunities are afforded to the amateur to exercise his refined taste in the selection of such materials as will produce the most harmonious results with regard to the arrangement of colours.

The objects of which we treat in this section are those which require the assistance of the graving-tool and one of the ornamental chucks for their production.

We may here offer a few remarks with regard to the arrangement of colour suitable to each style of turning.

As before stated, the only ornamental articles of which we purpose to treat are those which result from the application of the following apparatus:

The rose-engine-chuck, the straight-line-chuck, the pumping-chuck, the oval-chuek, and the eccentric-chuck.

In the production of various articles by means of these tools, it will be found that the most pleasing effects will be produced when the natural colours of the material vary in accordance with the position of the lines in the design.

Thus it will be generally desirable to use a material in such a position that the fibres of the material lay

parallel to the axis of the object to be turned, for if it is intended to produce an ornamental effect upon the cylindrical surface of the work, it will, in this case, offer a similar and uniform surface on all sides; and if, on the contrary, the design is to be produced upon the face of the work, the surface will also, in this case, be uniform, and will probably vary in colour from the centre to the periphery in concentric circles, which will materially add to the beauty of the work.

The amateur will, however, find that pieces of wood will occasionally present themselves which are specially suitable to some particular design, and when such occurs the materials should be laid aside in order that it may be applied to the purpose to which it is eminently suitable.

Where materials naturally tinted in a manner suitable to the desired work cannot be obtained, its place may be supplied in the following manner:

Let us suppose that a snuff-box is the article we are desirous of turning; then we will commence our operations by sketching out the design which we purpose to engrave upon it. This being done, we proceed to the selection of materials suitable to the work; the centre part may be made of a light-coloured material, outside which we will place a ring of a somewhat darker substance, accurately fitted to the periphery of the centre by turning and boring, and the whole diameter may be made up of other materials, gradually becoming darker in colour as they approach

the edge of the box, each colour carrying upon it some special design suited to its tint and to the material of which it is constructed.

Having completed our preliminary observations, we will proceed to describe the principal properties and characteristics of those woods which are included in the first class.

Alder stands first on the list, and we shall therefore, in the first place, direct our attention to this wood. These trees are to be found in Europe, Asia, North America, and the Himalayas, but the European and Asiatic are those from which our material is derived.

The common alder rarely exceeds forty feet in height. We may here observe that it is very durable for submerged structures. The colour of the alder is a reddish yellow, nearly uniform in any section, but varying in shade for different sections. The wood is soft, and the smaller trees are in great demand for inferior turnery, such as tooth-powder boxes, common toys, bobbins, &c. The roots and knots are beautifully veined, which property renders them valuable for cabinet and other ornamental work.

We next come to the beech. One species of this tree is common to the various countries of Europe. In Great Britain, the Buckingham and Sussex beech are generally esteemed the most valuable. The trees attain to an average hight of forty feet, by about two feet in diameter. The colour of this wood, which

may be called whitish brown, is influenced by the ground in which the tree is cultivated, and is described as white, brown, and black. This wood is very much used for plain stocks, tool-handles, lathe-chucks, cogs, keys, &c. Beech is stained to imitate rosewood and ebony, and it is considered to be almost chemically free from foreign matters. This wood is often attacked by worms when stationary, as in framings, but tools kept in use are not thus injured.

Birch-wood is derived from a forest tree common to Europe and North America; that which is held in the highest estimation is imported from Canada, St. John's, and Picton. This wood forms an excellent material for the turner, being light-coloured, compact, and easily worked, it is generally softer and darker than beech, nor does it bear any resemblance to it in grain. Birch-wood is not very durable; nevertheless, a considerable quantity of it is employed in the manufacture of furniture. Some of the wood is almost as handsomely figured as is Honduras mahogany, and when carefully and properly tinted and coloured, it is not easily distinguished from that beautiful material. The English birch is considerably smaller than the foreign, and lighter in colour, and is chiefly used in turning. Some of the Russian birch, commonly called Russian maple, is very beautiful, and of a full yellow colour.

We now proceed to discuss the properties of the sallow. This wood is white, with a pale-red cast; in

this respect not unlike the red deal, but it does not possess the veins visible in the last-mentioned material. The wood is very soft, and therefore only used for very common works, such as children's toys; like willow, of which it is a variety, it is planed into chips for the manufacture of bonnets and baskets. It splits well.

The willow is the last of this class, and of it there are many varieties. It is perhaps the softest and lightest of our woods; in colour it is tolerably white, inclining to yellowish grey. From the facility with which it is turned, it is in great demand for the manufacture of those boxes which druggists and perfumers provide with their powders and cerates.

We now proceed to the description of those woods which are included in the second class, and which are usually harder and closer in grain than the foregoing.

The first of these is holly. The wood obtained from this tree is very clean and fine-grained; the whitest and most costly are used by the manufacturer of Tunbridge-ware, by whom they are employed for a variety of his best works, which are subsequently painted in water-colours.

It is closer in texture than any other of our English woods, nor does it readily absorb foreign matter, which latter property renders it peculiarly valuable for the manufacture of painted screens, the squares of chess-boards, and various similar works.

The holly requires great attention in its treatment.

Immediately on its being felled it should be wrought into pieces of the form ultimately required, as planks, veneers, or round blocks for the use of the turner. The veneers are hung up separately to dry, as resting in contact for even the space of two or three hours would stain them. The round blocks are boiled in water for two or three hours, and on removal from the vessel in which they have been subjected to this process, they are thrown together in heaps, and closely covered up with sacking to protect them from the action of the atmospheric air, which would cause them to split. The heap is gradually exposed as it dries. At the end of about four weeks the blocks look greenish, and are covered with a mildew, sometimes as much as one sixteenth of an inch in thickness; this is brushed off at intervals of three or four weeks, and at the end of six months the wood will be fit for use.

Holly is a remarkably tough as well as clean wood, which renders it peculiarly applicable to the construction of chucks; but the troublesome preparation above detailed, the object of which is to whiten the wood, will then be unnecessary, although a thorough boiling greatly assists the extraction of the sap, and therefore the subsequent seasoning of the wood.

The next material to which we direct the attention of the student is the horse-chesnut.

This tree is in no way related to the Spanish or edible chesnut, which latter is more nearly allied to the oaks. The horse-chesnut is one of the white

woods commonly used by the Tunbridge turner. It is close, soft, and even in the grain, which properties render it very suitable for the production of turned works; it is much softer than holly, but is preferable to it for large painted and varnished works, on account of its superior size.

The sycamore is common to Europe. It is also called the great maple, and in Scotland and in the North of England it is known as the plane-tree. It attains to an average height of thirty-two feet. Sycamore is a very clean wood, with a figure not unlike that of the plane-tree; it is, however, much smaller. It is softer than beech, but rather disposed to be brittle. The colour of the sycamore, when young, is a silky white, and of the old tree a brownish white; the wood of middle age is intermediate in colour, and the strongest. Pieces of this wood may also occasionally be had which are very handsomely mottled. It is used in furniture, musical instruments, and for the superior kinds of Tunbridge turnery. Sycamore may be cut into very good screws, and is used for presses, &c.

A variety of sycamore which is called hare-wood is richer in figure, and sometimes striped, but it is, in other respects, similar to the above. Some of the foreign kinds are very beautifully marked by undulating lines, and such pieces as possess this quality are employed for the manufacture of the backs of the handsomest violins, the sounding-boards of which are made of a variety of larch.

The apple-tree now demands our attention. The woods of the various apple-trees, especially such as are obtained from those trees which are uncultivated, are generally tolerably hard, and of close grain; on the surface are reddish brown tints, somewhat lighter in shade than the hazel-nut. The butt of the tree only is used; it is generally very straight and free from knots up to the crown, whence the branches spread.

The apple-tree splits exceedingly well, and is one of the best woods for standing when properly seasoned: this wood is in great demand for the turned works in Tunbridge-ware, also for bottle-cases, &c.; the wood is clean working, and being harder than chesnut or sycamore, is far more suitable for the production of screwed-work than those materials, but it is inferior in that respect to pear-tree, which yields a tougher wood. The wood of the crab-tree is occasionally used for the teeth of mortice wheels.

The pear-tree is a native of Europe. The wood obtained from uncultivated trees is principally used, and these trees vary in diameter from six to fifteen inches. The colour is a light brown, somewhat similar to that of common mahogany and cedar, but it is generally less red than the apple-tree.

This is one of the brown woods of the Tunbridge turner, by whom a large quantity of it is used; it is esteemed very good for carving, as it cuts with nearly equal facility in all directions of the grain. It is now much used for the engraved blocks of the calico-

printers, paper-stainers, and pastry-cooks; it is not remarkably durable unless a very great amount of attention is bestowed upon it when undergoing the process of seasoning.

The last wood in this class of which we are treating is the plum-tree. The wood obtained from this tree, which is a native of Europe, is similar in general character to that produced by the pear-tree, and it is used principally in turning. This wood, on account of its being exceedingly handsome, is greatly used in Tunbridge works: in the cross section of the wood, that is to say on viewing it endways of the grain, it bears a very considerable resemblance to that derived from the cherry-tree, but in the older trees its tint assumes more of a reddish brown colour, with darker marks of the same colour. This wood generally begins to decay in small holes rather away from than in the centre of the tree, on which account it is very wasteful.

We now proceed to the consideration of the third and most valuable class of woods, the first of which is beech, which we have already considered in the first class; we therefore pass on to the second, namely, box, which is indigenous to Europe. There is also a variety obtained from Turkey; this latter is imported in logs about two feet six inches in length, and ranging up to fourteen inches in diameter, from Smyrna, Constantinople, and the Black Sea. The wood is yellow, inclining to orange; it has a thin

rind, with numerous small knots and protrusions; some of it has a considerable twist, and such pieces do not stand well when worked. It is, however, on the whole, an excellent, sound, and extremely useful material. Box-wood makes excellent lathe-chucks, and is selected by the wood engraver to the exclusion of all other woods; it is also used for a great variety of turned works. Some of the box-wood is very handsomely mottled, but it differs much in colour, apparently according to the age and the season in which it is cut, as only a small portion of the Turkey box-wood is of the full colour so much admired.

European box-wood may be obtained from Portugal, Leghorn, and elsewhere. The English box-wood is exceedingly plentiful at Box-hill in Surrey, and also in Gloucestershire; it is more curly in growth than the Turkish box-wood, and also softer and of a lighter tint than that material; its diameter does not usually exceed six inches; it is used for common turnery, and is very valuable for lathe-chucks, as it is tougher than the foreign box and bears rougher usage. This tree is of very slow growth, as in the space of twenty-five years it will scarcely attain a diameter of two inches. A similar wood imported from America, under the name of tugmutton, was formerly much used for ladies fans.

The elm is a European timber tree, of which there are five species; in height it averages forty feet, and two feet six inches in diameter. The heart-wood is

a reddish brown colour somewhat darker than the oak; the sap-wood is a yellowish, white with pores inclining to red; the wood is porous, cross-grained, and shrinks very much in drying. Elm is not liable to split, and bears the driving of nails, screws, &c. better than any other kind of wood; it is also very tough, and therefore valuable for the purposes of common turnery.

Wych-elm and rock-elm are also used in the arts, but as the turner seldom requires them, we shall not encumber our space with a description of these materials.

The oak.—Of this valuable timber there are two kinds indigenous to England, and several others to the Continent and America. This wood, when of the best quality, is far superior as regards durability than any other wood that attains to the same size. Its colour is a well-known brown. Oak is a most valuable wood for all works which require great strength, or have to withstand continual exposure to the weather.

The English oak is one of the hardest of the species, it possesses a much greater degree of hardness than either the white or red Canada oak, and it is also possessed of the same superiority over the wainscot oaks from Memel, Dantzic, and Riga.

The wainscot oak of Norway is remarkably straight and splits with great facility, so much so, indeed, that it is a practice of the country of which it is a native

to bore a small hole in the top of the tree at the beginning of winter which is subsequently filled with water, the expansion of which in freezing rends the tree from top to bottom.

The live oak and the African oak are also converted into timber, but for reasons already enumerated we shall pass these over in silence.

This completes the account of the hardest English woods, and we shall now proceed to the consideration of that more numerous body included in the ornamental foreign woods, most of which are more costly than those already referred to.

The first foreign wood to the properties of which we are now desirous of calling the amateur's attention is the Amboyna-wood, otherwise termed the Kaibooca-wood. This wood is imported from Singapore, and appears to be the excrescence or burr of some tree of considerable size; it is sawn off in slabs from two to four feet long, four to twenty-four inches in width, and from two to eight inches in thickness: it resembles the burr of the yew-tree, is tolerably hard, and full of small curls and knots. The colour varies from orange to chesnut brown, and sometimes red brown. It is a very ornamental wood, and is also held in high estimation in China and India, where it is used in the construction of boxes and writing-desks, and other ornamental works in the same manner as by ourselves.

Beef-wood next demands our attention. This is a

name frequently applied to a great variety of red woods, but by it the Botany Bay oak is generally supposed to be expressed. This wood is obtained from New South Wales; it is shipped in round logs from nine to fourteen inches in diameter. In general colour it bears a marked resemblance to full red mahogany with dark red veins; the grain is more like the evergreen oak than the other European varieties, as the veins are small, slightly curled, and very closely arranged throughout the surface. It is used for veneer, Tunbridge-ware, and turning. Some specimens are very beautiful.

The next material to the description of which we must betake ourselves is the universally admired ebony.

This substance is said to be obtainable in various colours as red, yellow, green, and black. The existence of the red and yellow ebonies appears questionable. The black ebony is the species invariably referred to when the name is mentioned alone. The wood is surrounded by a white sap three or four inches thick. The green ebony is an entirely different tree, with a thin smooth bark, growing in the West Indies. Three kinds are imported: No. 1, from the Mauritius, is imported in the form of round sticks, resembling scaffold-poles; they seldom exceed fourteen inches in diameter; No. 2, the East Indian, which grows in Ceylon, the East India Islands, and the continent of India; this is mostly shipped from

Madras and Bombay in logs varying from six to twenty-eight inches in diameter, and also in planks; and No. 3, the African ebony, shipped from the Cape of Good Hope, in billets, the general size of which varies from three to six feet long, three to six inches wide, and two to four inches thick; these are rent from the tree, and thence frequently called billet-wood.

No. 1, the Mauritius, is the blackest and finest in the grain, as well as the hardest, and by far the most beautiful of the three above mentioned species; but it also suffers under the disadvantages of being the most costly and most unsound; No. 2, the East Indian, is not nearly so wasteful as the foregoing, but is far inferior to it in grain or colour, and No. 3, the African, is the least wasteful, as all the refuse is left behind, and all that is imported is usable; but it is the most porous, and worst in point of colour.

All these species are used for cabinet, mosaic, and turned also for flutes, the handles of doors, knives, &c.

The African stands the best, and is the only sort used for sextants.

Green ebony is obtained from Jamacia, and the West Indies generally, it is cut in lengths of from three to six feet, the heart-wood is of a brownish green colour. This material is used for round rulers, turnery and marqueterie work, and it cleaves exceedingly well.

The foreign box-wood which stands next upon our list has already been noticed in a former page.

Brazil-wood, called also Pernambuco, is supposed to have been known as a dye-wood before the discovery of the Brazils, which country is said by some to have received its name on account of its abounding in this material. The best kind is from Pernambuco, where it is called Pas da Rainha, or Queen's-wood, and by the natives Ibirapitanga. The tree is large, crooked, and knotty, and the bark of such extensive thickness that the wood only equals one third or fourth of the entire diameter. Brazil-wood is a royal monopoly, and the best kind has the imperial brand at the end; it is shipped in trimmed sticks from one to four inches in diameter, and three to eight feet long; its colour becomes darker by exposure to the air; its principal use is for dying, but the best pieces are selected for violin-bows, and for turning.

We will now treat of Braziletto. This wood is quite dissimilar from the foregoing; its colour is a ruddy orange, sometimes streaked. It is imported from Jamaica in sawn logs, from two to six feet long, and two to eight inches in diameter, with the bark, which is of ordinary thickness, left on. This wood is applied to the same purpose as the Brazil-wood.

Bullet-wood, from the Virgin Isles, West Indies, is the produce of a tree of considerable size, of which the sap is white; the wood is of a greenish hazel colour, and in texture close and hard. Another spe-

cies of this wood, which is supposed to come from Berbice, is of a hazel brown colour, of an even tint without veins; it is very close, hard, and good wood, well adapted for general and eccentric turning, but is somewhat rare.

Cocoa-wood, or cocus, is imported from the West Indies in logs varying from two to eight inches in diameter, sawn into lengths of from three to six feet; it is tolerably free from knots, with a thick yellow sap; the heart, which is rarely sound, is of a light yellow brown, which when first cut is streaked with hazel or darker brown, but it changes on keeping to a deep brown, sometimes almost black. Cocoa-wood is much used for turnery of all descriptions, and is peculiarly adapted to those objects which are to be ornamented on the eccentric chuck.

Coromandel and green ebony are of the same genus with true ebony, the properties of which are detailed above.

Green-heart, from Jamaica, Demerara, and the Brazils, bears a general resemblance to cocoa-wood both in size and bark, but the latter has a redder tint. Green-heart when first cut is of a light greenish brown colour and striped, but it changes to the colour of lignum-vitæ, and is by some considered to be pernicious; it is used for turnery and other works, but its texture is coarse, and it will not cleave at all profitably. Grenadillo, which is imported from the West Indies, is a lighter description of the common

cocoa, but changes ultimately to a dark colour, although more slowly. Iron-wood is imported from the Brazils, the East and West Indies, and other countries, in square and round logs from six to nine inches and upwards. The colours are very dark browns and reds; sometimes streaked, and generally straight-grained. The iron woods are commonly employed by the natives of uncivilised countries for their several sharp-edged clubs and offensive weapons; in England they are principally used for ramrods and walking-sticks, and also for turning, as well as for various purposes requiring great hardness and durability; the more red varieties are frequently called beef-wood.

King-wood, also known as violet-wood, is imported from the Brazils is trimmed logs from two to seven inches in diameter, generally pipy or hollow in the heart. It is beautifully streaked in violet tints of varying shades; it is of much finer grain than rose-wood, being principally used for turning and small cabinet work. It is, perhaps, one of the most magnificent hard woods with which we are acquainted. Lignum-vitæ, or guaiacum, is imported from Cuba, Jamaica, Saint Domingo, and New Providence, in logs varying from ten and a half to thirty-six inches in diameter; it is one of the hardest and heaviest of woods. When first cut it is soft and easily worked, but it becomes exceedingly hard on exposure to the air. The wood is cross-grained, covered with a smooth, yellow, sap-like box, almost as hard as the

wood, and contains a large quantity of the gum guaiacum, which is extracted for medicinal purposes. Lignum-vitæ is much used for machinery, &c., for rollers, presses, mills, pestles, mortars, sheaves for ship-blocks, skittle-balls, peg-tops, and other articles requiring great hardness and durability. The fibrous structure of this wood is very remarkable, the fibres crossing each other at an acute angle. The wood can hardly be split, and is therefore divided with a saw, and when thin pieces, such as old sheaves, are broken asunder they exhibit a fracture which in appearance has rather the properties of a mineral than a vegetable substance.

Locust-tree.—The wood of this tree is of a greenish yellow colour, with a slight tinge of red in the pores; it is used like oak. Locust is much esteemed for all purpose requiring toughness and durability, and is very suitable for turned works.

Mahogany is a native of the West Indies and the country round the bay of Honduras. In growth it is very rapid, and its trunk frequently attains a height of forty feet with a diameter of six feet.

Spanish mahogany is imported from Cuba, Jamaica, &c., in logs from twenty to twenty-six inches square, and ten feet long. It is close-grained, hard, sometimes strongly figured, and generally of a darker colour than Honduras mahogany, but its pores frequently appear as if chalk had been rubbed into them.

Honduras mahogany is imported in logs of larger

size than the above; it is generally lighter than the Spanish, and also more open and irregular in the grain: many of the pieces are, however, extremely beautiful, being of a fine golden colour, with showy veins or figures. The worst kinds are those which present the appearance of being filled with grey specks, from which Spanish mahogany is comparatively free.

African mahogany, from Gambia, is a more recent importation; it twists much more than either of the above, and is decidedly inferior to them in all respects save hardness; it admits of being turned with equal facility with the others.

Mahogany shrinks but little in drying, and twists and warps far less than any other wood; it also holds glue the best of all. Mahogany is used for a great variety of turned works. The Spanish mahogany is usually the best, though it is very nearly approached in quality by the Honduras, which, however, is inferior to it in hardness and weight. There are two other varieties of mahogany, but neither of them are commonly used in this country.

Maple is considered to be allied to the sycamore, which is sometimes called the great maple or plane tree. The English or common maple is of this kind; in colour it is a pale yellowish brown; it is much used for Tunbridge-ware. The American variety is very beautiful, and is called bird's-eye maple or mottled maple.

Mustaibas, generally known in England under the

name of Mosatahiba, is imported from the Brazils and Rio Janeiro in logs about seven inches by ten, also in planks; it is similar to rose-wood, but usually inferior to it. It is, nevertheless, harder, and occasionally equally good; the veins are of a chesnut brown, running into black. In its grain it resembles some of the iron woods; it has fewer resinous veins than rose-wood. Some of better kinds are very good for turning, the wood being close, sound, and heavy.

Olive-wood.—This wood, which is much esteemed on the Continent for making embossed boxes, is imported from Leghorn; it is much like box, but softer, with dark grey veins. The roots have a very pretty knotty and curly character. There is another wood supposed to come from South America, also called olive-wood; it is of a greenish orange colour, with broad stripes, and marks of a dark brown tint, it is a very handsome wood for turning, but is not very hard.

Partridge-wood.—This material is obtained both from the Brazils and the West India Islands; it is imported in large planks, or in round and square logs; the wood is close, heavy, and generally straight in the grain. The colours are variously mingled, and most frequently disposed in fine hair-like streaks of various shades, which, in some of the curly specimens, bear a striking resemblance to the feathers of the bird from which this wood takes its name.

It may be used with advantage for the production of handsome turned works.

Peruvian-wood is a fine sound wood, in character resembling rose-wood; it measures from twelve to sixteen inches through; it is harder, closer, and lighter in colour than rose-wood, and its veins, which are more closely distributed, are varied with reddish brown and black tints. This wood is known by the above name, its true name and locality being unknown.

Princes-wood, from Jamaica, is imported like cocoa-wood, of which we have given a description; its veins are of a very light brown tint, and it is principally used for turning.

Purple-wood, from the Brazils, is imported in baulks twelve inches square, and eight to ten feet long; its colour is a dark grey when first cut, but it changes rapidly, and ultimately becomes a dark purple; it is used for buhl-work and turning.

Red Saunders or ruby-wood is chiefly imported from Calcutta, in logs from two to ten inches in diaameter, and occasionally in roots and split pieces; it is very hard and heavy, and much used in turning.

Rosetta-wood is an East Indian wood of very considerable size; in colour a brilliant red orange, it is handsomely varied by veins of a dark tint; the wood is hard and very beautiful when first cut, but soon becomes darker.

Rose-wood, also produced in the East Indies, as

well as in the Brazils, Canary Isles, and Africa, is imported in very large slabs. The best is from Rio Janeiro, the second quality is from Bahia, and the most common comes from the East Indies. The East India rose-wood appears to have little or none of that resinous substance, from which the odour arises, disseminated through its pores. Rose-wood contains a very considerable amount both of gum and oil, on account of which quality the small splinters make excellent matches. The colours of rose-wood are various, ranging from a light hazel tint down to a dark purple; the tints are sometimes strongly and abruptly contrasted, and at other times the surface very nearly approaches uniformity. The wood is very heavy; some specimens are close and very fine in the grain, whereas others are as open as coarse mahogany, or rather are exceedingly abundant in veins. The black streaks in this wood are exceedingly hard, which renders them excessively destructive to tools.

The abundance of this material is only second, as far as regards the furniture wood, to that of mahogany. A very considerable quantity of it is reduced to the condition of a veneer, and subsequently applied to the purposes of the cabinet-maker. Solid pieces of the wood are also used for the same purpose, and also for a great variety of turned works of ordinary consumption.

Sandal-wood.—This wood is the produce of a tree

in appearance not unlike a large myrtle. The wood is extensively employed as a perfume, on account of the refreshing odour it exhales; it is very frequently used in the funeral ceremonies of the Hindoos.

The colour of this valuable product of nature is a yellowish brown, and those varieties are the most valúed for their perfume of which the tint is darkest, and which are procured from the lowest parts of the trunk. Malabar produces the finest sandal-wood; it is also found in Ceylon and the South Sea Islands. It is imported in trimmed logs; the wood is in general considerably softer than box-wood, and is excedingly easy to cut. It is used for parts of cabinets, card-cases, fans, and other ornaments. The bark of the sandal-wood gives a most beautiful red dye.

Satin-wood—The best variety is shipped from St. Domingo, the second in quality is obtained from Singapore, and the most inferior from New Providence. The wood is close, and although inferior in hardness to box-wood, and of a somewhat darker tint, it nevertheless bears a very great assemblance to that useful substance; it is very close in the grain, and specimens are occasionally obtained having a very beautiful curled or mottled appearance. It is occasionally used for turning.

Snake-wood is used at Demerara, Surinam, and also along the banks of the Orinoco, for the manufacture of the bows of the Indians. The colour of this material is red hazel, with numerous black spots and

marks, which have been supposed to bear some resemblance to the scales of the reptile. This wood is very beautiful, but it is scarce in England, and chiefly used for walking-sticks, which are of great price.

Tulip-wood next demands our attention; it is trimmed and cut like king-wood, but is usually unsound in the centre. The wood is of a flesh-red tint, with blood-red streaks; it is very handsome, but it fades. This wood is very wasteful and splintery; it is used in turning Tunbridge-ware and for brushes.

Yacca-wood is imported from Jamaica in short crooked pieces like roots, from four to twelve inches thick; the wood is pale brown with streaks of hazel brown; it is principally used for cabinet-work and turnery. Some specimens are very handsome.

Zebra-wood is the produce of the Brazils and Rio Janeiro. It is of an orange brown colour mingled with a dark brown, which latter is sometimes in straight stripes. It is very handsome, and therefore very suitable for ornamental turned works.

Cam-wood, the last of which we treat, is shipped from Rokella, Sierra Leone, in short logs, roots and splinters. When first opened it is tinted with red and orange, but its colours soon change to a dark red and brown. Cam-wood is the best and most durable of the red dye-woods; it is exceedingly fine and close in the grain, and therefore suitable to ornamental and eccentric turning.

Having now completed our description of the various kinds of English and foreign woods, a knowledge of which will be extremely useful to the ornamental turner, we think it advisable to suggest the most appropriate means of ascertaining the colours and general appearance of these materials by actual examination, as, by taking this step, the amateur will be enabled to recognise the various specimens which he may be desirous of purchasing, thereby excluding all possibility of being deceived in this matter, either by the ignorance or design of the dealer.

The institutions which immediately offer themselves as being highly suitable for the prosecution of this interesting study are the many beautiful public and private museums, of which there are such a great number in the United Kingdom.

For those residing in the metropolis and its suburbs, there is no place more highly calculated to afford them that information for which they are seeking than that magnificent and deservedly celebrated collection enclosed within the walls of the British Museum.

We cannot take leave of this subject without also calling the reader's attention to some others of our metropolitan institutions, among which the India House Museum, as far as regards the collections of which we speak, is scarcely to be excelled.

We may also recommend to the metropolitan student a survey of the collection which may be seen

in that institution which has been erected with the surplus funds in the hands of the commissioners of the National Exhibition of 1851, commonly known as the Kensington or Brompton Museum.

We may conclude our remarks with the mention of the museum in the Botanical Gardens at Kew, the Crystal Palace, &c.

We deem it desirable now to proceed to the consideration of the nature and properties of those materials with which the amateur will work, and which are not included in the foregoing pages.

Under this head we shall include horn, ivory and shell, the most important of which is ivory.

The chief source of ivory exists in the tusks of male elephants, and may be divided into two classes — Asiatic and African. The tusks are usually solid for about half their length, of circular or elliptical section; it is very dense and compact, and, although distinctly fibrous, it cannot be split into thin laminæ; this material admits of being worked with exquisite smoothness, and it is capable of receiving the most delicate lines and figures, and may be reduced to such proportions as none of the woods will sustain. From this it appears that this material is supremely useful for all kinds of ornamental turning.

The hippopotamus supplies ivory which is much harder and far more valuable than that of the elephant, its colour is of a purer white, and it is almost free from grain. The circular teeth are coated with

an excessively hard enamel, which entirely resists the action of steel-edged tools; it is therefore usually removed upon the grindstone. This material is that employed by the dentists, and those pieces rejected by them are used for small carved and turned works.

The African ivory, when of the first quality, appears upon cutting to present a warm semi-transparent tint, with little or no appearance of grain or fibre. After the material has been exposed for some time the oily substance which imparts to it this appearance dries up, leaving the material of a delicate and generally permanent tint, somewhat darker than writing-paper.

The Asiatic ivory is of a more opaque, dead-white appearance. On being freshly cut it presents the ultimate appearance of African ivory, but it is very liable to become yellow by exposure.

The African ivory is much closer in texture than the Asiatic; it is also harder under the tools, and its surface is capable of receiving a finer polish; its density, however, also prevents it from readily absorbing oil or the colouring material of stains.

Ivory requires a similar drying or seasoning to that recommended for wood, as, if the teeth be cut up and the pieces exposed to hot dry air without having been previously prepared, they crack and warp, and the larger the pieces the greater the risk: on this account ornaments produced from this ma-

terial should not be placed on a chimney-piece which is so near the fire as to become warm.

Ivory alters in length as well as width; the change, however, in direction of its length, is much less than that which takes place in the direction of its width. There is a remarkable instance in which this may be frequently observed, namely, in the construction of billiard-balls, for, if the room in which they are kept be of a sensibly different temperature to that in which the balls were manufactured, a difference between the two diameters will soon be exhibited. The balls are usually reduced roughly to the form of a sphere some months previous to their being finished, in order to allow the material of which they are composed to become thoroughly dry, and some clubs are sufficiently judicious to take the precaution of keeping the ivory in their own billiard rooms previous to its conversion to the finished article.

We now proceed to make a few observations upon some of the shells used for the manufacture of various ornamental articles.

In some shells the quantity of animal matter is very small, their being chiefly composed of lime, and this in so dense and compact a form that the shells are brittle and semi-transparent, having smooth surfaces incapable of being cut with steel tools. Such shells are called porcelainous, and they can only be worked by a lapidary's wheel, or other similar contrivance, with emery and other gritty

matters which exceed the shell in hardness. This class includes most of the univalve shells, such as the whelks, limpets, and cowries.

There is another class of shells termed nacreous, from *nacre*, the French word for mother-of-pearl, and these are the most commonly known in the shells of the pearl-bearing oysters of the Indian seas. But the class also includes nearly all the bivalve shells, such as the various oysters, mussels, &c. These shells are usually smooth and iridescent on the inner surface, on the outer they are usually covered with a rought coat.

The beautiful colours which appear on the surface of the pearl shells is very possibly due to the interference of light produced by the varying thickness of the nacreous laminæ.

On account of their lamellar structure, they are capable of being split for the manufacture of thin articles, such as card-counters, sides of penknives, &c., but, as in splitting, the pieces thus obtained follow the curvature of the shell, this method is not usually resorted to, but pieces are selected which are most suitable to the object for which they are designed, the excess of thickness being removed upon the grindstone.

The usual process followed in the preparation of the pearl-shell for the arts, is as follows: the square pieces are cut out by means of the brass-backed aw, and the circular by means of a crown-saw at-

tached to the lathe-mandril; the sides of the piece are then ground flat upon a wet grindston.

The shells from Manilla are by far the best; they are very large and brilliant, and their edges are of a yellow tint. Fine large shells, in colour dead white, are obtained from Singapore, and very common ones from Bombay. Common shells, with jet black edges, are obtained from Valparaiso, and some with white edges from the South Sea. Cameos are cut from a conch shell, found on the Southern coast of America and the West India Islands.

The bones of animals are also used for the manufacture of ornamental and useful works. They are much less brittle than the shells, but require to be prepared in order to render them fit for use. This preparation consists in boiling them in water, and bleaching them; this process of boiling removes a considerable portion of their gelatine, whereby they are rendered more brittle, and having a fibrous structure, they break in splinters. The buttock and shin bones of the ox and calf are almost the only kinds used for the purposes of turnery. To whiten the finished works, they are soaked in turpentine for a day, boiled in water for an hour, and then polished with whiting and water. Bone is far less disagreeable under the tools than the pearl-shell, but it nevertheless feels somewhat hard and chalky; the screws cut on bone are imperfect, and very liable to injury. It is harder, and frequently much whiter, than ivory.

We next proceed to the consideration of horns. Horn consists chiefly of animal matter, namely, coagulated albumen and gelatine, which latter enables them to be considerably softened by a degree of heat not exceeding six hundred degrees Fahrenheit; after which they may be cut open, flattened into sheets, divided into thin laminæ, and moulded between dies like metal.

The first step in the preparation of horn has for its object the separation of the bony core which composes the central part of this product: this is effected by macerating the horns in water for about a mouth, after which the bony core may readily be detached from the superincumbent horn by reason of the putrefaction of the intermediate membrane.

For the manufacture of drinking horns and some other turned works, the material is cut to the appropriate length, and moulded by being placed in a conical hole, in a heated iron, while a heated conical plug is driven into it, after which it is allowed to cool in the mould, when it will be ready for the use of the turner.

The next material to which we direct our attention is tortoiseshell: the animal from which this is obtained is a marine tortoise, known as the hawk's-bill turtle.

The usual size of the full-grown animal is about a yard long, and three-quarters wide; its shell consists of thirteen principal plates, five down the centre of

the back and four on each side, the largest of which weigh about nine ounces, and measure about thirteen inches by eight, and a quarter of an inch thick at the central part. Some of the shells are very thin, and appear to consist of a single lamina; this is supposed to occur when the animal loses the shell by accident, or when it is stripped and thrown back into the sea alive; such shells are usually very light-coloured, and are known by the name of yellow-belly. There are also twenty-five small pieces of shell, which envelop the sides of the animal, but these can only be applied to very small purposes.

The qualities of tortoiseshell are as follows: Manilla, fine and large; Singapore, nearly as good; West Indian, large and heavy, and of a reddish colour; Honduras, dark coloured with dark red spots; Calcutta, dark, heavy, and of bad colour; Bombay shell, the last, and exceedingly scabby, from the attachment of barnacles, limpets, &c. There is also the loggerhead tortoiseshell, which is almost useless, and the yellow-belly, whose plates are very thin.

Of the turtleshell, that of Columbia is decidedly the best, fine and very dark; Jamaica, light-coloured and very inferior; East Indian, of middling quality, but seldom met with. The small fishes are called chickens, and their markings are diminutive.

The treatment of tortoiseshell is essentially the same as that of horn, but on account of its much greater expense it is economised as far as possible.

Before the shells are worked, it is desirable to steep them in boiling water for the purpose of tempering them; three or four minutes will commonly be sufficient to temper them, but they require a longer period for their immersion, when they are either thicker or more brittle than is usually the case.

Before concluding our description of materials, we must notice one of somewhat delicate character, which is employed for the manufacture of the bodies of small vases intended for ornament. The material to which we allude is egg-shell. Very elegant articles may be produced from this animal product, but the top and bottom of the vase must be made from some more suitable substance. These may be wrought and fastened together according to the method detailed in another part of this treatise.

In the preparation of various articles by means of the lathe, the operator will find that when working with very soft material a great velocity of the lathe-mandril will be necessary, and as the materials become harder, this velocity must be reduced.

APPENDIX.

ORNAMENTAL TURNING.

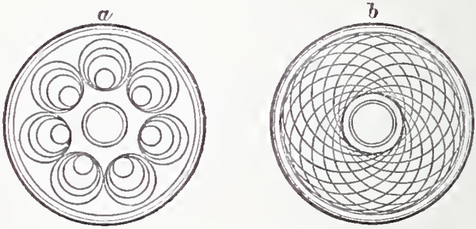
Having in a former chapter described the construction of some of the simpler forms of apparatus which are used for the production of turned devices, we think it now desirable to illustrate and describe the application of these curious tools.

The first chuck of which we have to consider the action is the eccentric-chuck, and we will commence our remarks by describing the manner in which it is to be adjusted.

The eccentric circles are in reality turned concentric to the lathe-mandril, but not to the axis of the work, the method of setting it is this: The screw by which the slider is moved is caused to revolve, until the axis of the click-plate is at a distance from that of the lathe-mandril, which is equal to the eccentricity of the required circle: a proper graver being fixed in the slide-rest, and the work being attached to the chuck

carried upon the screw of the click plate, the lathe may be set in motion, when the eccentric circle will be produced. A ring of these circles may be formed by turning the click-plate through a certain portion of a revolution after the production of each individual circle.

Fig. 93.



In the accompanying figure we have shown two designs capable of being produced by the eccentric-chuck, and we will explain the method of carving them, supposing that the design shown at *a* is to be carved on the top of a snuff-box, and that at *b* on the bottom. The snuff-box having been turned plain, of some hard and suitable material, those circles which are concentric with the cover are cut upon it. It is then removed in its chuck from the lathe-mandril, and the eccentric-chuck is screwed on; that chuck which carries the work is then fastened on to the click-plate, according to the manner hereinbefore described. A circle is now traced lightly, concentric with the work, with a fine-pointed lead pencil, the circumference of which passes through the centres of

the largest intended eccentric circles; this circle is now carefully divided upon its circumference into as many equal parts as there are to be eccentric circles, which in the present case will be seven, each division will then show the position of the centre of a circle. The circle-plate is then moved to such a distance from the centre of the lathe-mandril as will give the required degree of eccentricity, and this distance will be equal to the radius of the pencilled circle; an eccentric circle is then cut by bringing up the point of the cutting-tool to half the distance between two divisions on the divided circle on the work, and causing the lathe-mandril to revolve; this circle cut to the required depth, the click-plate is caused to revolve until the point of the cutting-tool is midway between two other central points, and another circle is cut, and this process is repeated until the seven large circles are all cut.

The whole of the above manipulations must be repeated with each series of circles, with the exception of the adjustment of the tool, which will be brought, before cutting each circle, to that point in the circumference of the largest eccentric circle which is nearest to the centre of the work. These circles being completed, all that is necessary to finish this part of the work will be the engraving or setting of some device in the centre part of the disc.

We must now consider the steps to be taken for the execution of the design intended to be engraved

upon the bottom of the box, which is much more simple than the foregoing, consisting of only one set of eccentric circles. It is shown at *b*.

All that will be necessary to effect our present purpose will be to trace, as before, a circle by which to fix the eccentricity of the ornamental circles; this circle being traced, must be divided into sixteen parts, and one of these centres being brought to a proper position, by means of the click-plate, the tool is adjusted at a distance from the central point, equal to the radius of the circle, and the eccentric cut as above directed, and the same method followed out for all the others.

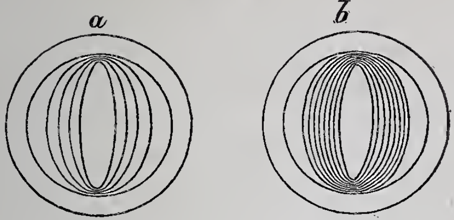
This design evidently differs from the first in two particulars, namely, in the diameter of the eccentric circles being greater than the radius of the work, whereas, in the first design, it was less; also, the circles intersect each other, instead of being merely in contact.

The two parts of the box being complete, all that is necessary will be to hold some fine shavings, or dust, against it, in order to impart to it some degree of polish.

The tool which will be found most convenient for the production of these ornamental lines is a fine graver, or point-tool.

The amateur having successfully produced these simple designs, we may proceed to the carving of another kind of figure.

FIG. 94.



The sketches, fig. 94, represent designs composed of four and eight ellipses, the major axes of all the systems dividing the work into eight equal segments. Each system of ellipses is of the from represented at *a* or at *b*.

We will suppose that it is intended to ornament a small circular box with this design. The work being reduced to a true condition, it is removed in its chuck, and attached to the elliptic-chuck, which is then set to produce the ellipse having the greatest variation from the circular form, which will be the smallest, and which is then chased. The chuck is now set to produce the next ellipse, and the above operations continued until all the ellipses are complete, and the circular form arrived at.

The click-plate is now turned through the eighth of a revolution, and the whole process above detailed is again repeated; and this being reproduced at equal intervals, the tool will, after chasing eight systems of ellipses, arrive at the point from which we started, when the work will be complete.

Although the effect produced by the above manipulations has a very pretty and complicated appearance, its principles are, in fact, very simple, and its execution a matter of no great difficulty.

Fig. 95.

In fig. 95 we have shown the most simple of those designs produced by the rose-engine, or any of the contrivances by which it may be replaced; it consists of a series of segments of circles, with their convexity towards the centre of the work. The method of working in the execution of this design is as follows:

The work is attached to the ordinary chuck, which is attached to the mandril of the rose-engine, as is also a rosette of a suitable form; the rubber is then adjusted, and the tool being set a proper distance from the centre of the work, the lathe is put in motion, when one series of circular segments will be cut, that is to say, one ring of them. The graver is now withdrawn, and again applied to the work somewhat nearer its centre, whereby a ring of segments will be produced within the above series.

These manipulations are continually repeated until the whole surface intended to be figured is covered with the circular segments. This style of ornamentation is much used for the backs of watches.

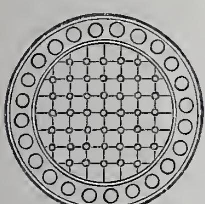
By various alterations and combinations a very considerable range of rose-engine patterns may be

obtained; thus, if we carve various systems of segments upon a disc, altering the position of the click-plate between every series, we shall obtain a curiously reticulated design. If the rose-engine be combined with the oval chuck, or with the eccentric chuck, we may produce a series of segments, arranged, in the one case, in an elliptical form, but, in the other, in a circular form, in the position of an eccentric circle.

If the rose-engine be used with the straight-line chuck, we obtain waved lines, passing across the disc in a transverse direction. When the pumping motion is used, the periphery of a cylinder may be ornamented with waved lines; and if this be done, and the screw-cutting lathe properly adjusted, the pumping motion being imparted to the work, not to the tool, a waved spiral may be executed, the form of the waves, both in this and in the foregoing cases, depending solely upon the form of the rosette used.

We shall now describe the construction of a variety of articles which require the application of one or more of the foregoing chucks for their execution, without previously specifying what apparatus we may require.

Fig. 96.



In fig. 96 is shown the form commonly adopted for the ornamentation of card counters. There are two methods by which it may be produced: one of which consists in turning the concentric circles in the lathe, and producing

the others by a small crown-saw, the straight lines being chased by a graver, guided by a straight-edge; the other method is more troublesome and less expeditious, and consists in producing the work complete in the lathe.

If the amateur be desirous of exercising himself by employing the second method, he may proceed in the following manner: Having marked out the various terminations of the transverse lines on the circumference of the inner concentric circle, they may be produced by means of the straight-line chuck; after which the small circles of the intersections of the lines may thus be produced: Let the work be fixed upon the eccentric-chuck, and each intersection be brought consecutively to the position of the axis of the lathe-mandril, and the circle cut by means either of a small drill, or exceedingly fine point-tool, or graver. For the adjustment of the various intersections of the straight lines, in order to cut the small circles, both the slider and the click-plate will have to be used, and they should be adjusted in the following order: First, set the work so that the centre intersection may be operated upon; the centre circle having been cut, all the other circles on the same diameter are produced, the requisite adjustment between each being effected by means of the slider. The click-plate is then passed through a part of a revolution corresponding to the angular distance between two intersections, and all the circles upon the diameter to which the tool is now brought are executed in a

similar manner to those on the first diameter. These processes must be repeated until all the intersections have been marked.

We next proceed to the execution of the eccentric circles contained between the two concentric circles in proximity to the edge of the work; and these may be chased with a fine graver, the work being adjusted for the execution of each circle, according to the manner explained in our observations on the production of eccentric circles, as shown at *a*, fig. 93.

The most suitable material for these articles are mother-of-pearl.

Fig. 97.

Fig. 95 represents a wooden ring-stand, of which various elegant and pleasing forms may be produced by means of the various ornamental chucks. We shall first briefly describe the method of turning the plain form, or blank, which is intended to be ornamented. A convenient piece of wood having been selected, it must be firmly fixed between the prong-chuck and back centre, unless it be so small as to be conveniently held in a cup-chuck; we will, however, suppose the former method is adopted.

The material is now roughly reduced to the form of the required article by means of various gouges. A template corresponding to the required form is now prepared, and the operator, guided by this template, reduces the work accurately to the condition of a blank ready to be ornamented, by means of a point-tool and

chisels with rounded ends; sufficient material only being left at the centre of either end of the work during this and subsequent operations.

During the processes employed for the ornamentation of the work, as the back centre cannot be used, except two similar chucks be employed, which would not be convenient, the blank must either have sufficient material left on it to allow of its being fixed in a cup-chuck, or otherwise it must be attached to a face-plate having a long, thin, and accurately-formed screw at its centre, and very light cuts must be taken, to avoid the risk of displacing the work.

The first process which we shall put into execution will be the carving of vandyked or undulating lines, both inside and out, near the edges of the cup or tray, and this is effected by means of a pumping-chuck of suitable form. A similar waved line may be produced near the periphery of the foot of the stand; similar devices may also be carved on the stem by means of the pumping-chuck, and the tray and foot may be further ornamented by the use of the eccentric and elliptic chucks.

It is evident that those parts of the foot of the stand which are concealed by the tray, and those parts of the tray which are concealed by the foot, cannot have eccentric circles cut upon them by means of the ordinary eccentric-chuck, as in this case the part of the work which is not being operated upon would come in contact with the cutting-tool, thereby arresting all further progress; we must, therefore,

if we desire to execute such designs in these positions, have recourse to a small eccentric-cutter, fixed upon a stand of suitable form.

We can, if it be required, readily execute on this article a design consisting of ovals, arranged as shown at fig. 94, the cutting-tool being made with a crank or bend in its stem.

In cutting eccentric circles or ellipses, or, in fact, any kind of turned device upon the internal surface of the cup or any other spherical or conical part, it must be borne in mind that the figure thus produced will be very different from that which the same adjustment of the apparatus would effect upon a plane disc; for instance, if we arrange the eccentric-chuck in such a manner as to produce an eccentric circle on a disc, and, with this adjustment operate upon the internal surface of the cup, rather near the edge, the result will be an egg-shaped oval, having its largest end nearest the centre of the work.

By thus attending to the effects which may be obtained by acting upon variously carved surfaces, we may produce various beautiful effects which could not otherwise be obtained; but it must be borne in mind that when the tool is required to act upon a surface which is not, at every point, equidistant from the plane of the face-plate upon which it is turned, a pumping motion must be imparted to the tool, in order that it may take an equal cut at every part of the figure; and this pumping motion may, when hard materials are used, which are, on account of their

hardness, caused to revolve slowly during the process of turning, be imparted to the slide-rest, by working the screws by means of which it is adjusted.

Longitudinal grooves such as those requisite for the production of a fluted stem, may be produced by bringing the eccentric-chuck to such a position that the work is concentric with the mandril, then fixing it so that it cannot revolve, after which the groove is cut by a mould-tool of suitable form being fixed on its side in the slide-rest, which latter is traversed along the bed of the lathe. One groove being thus produced, the click-plate is caused to revolve through that portion of a revolution which corresponds to the number of flutes required; thus, if eight flutes are intended to be produced, it will be necessary to cause the click-plate to perform one-eighth of a revolution between the carving of any two consecutive flutes. The rounded ends of the flutes may be produced by a combination of the rose and pumping action, or by causing the support of the tool to rub against a segment of a globe, the periphery of which is carved according to the form of the ends of the flutes.

In a somewhat similar manner we may form radial grooves in any work which we are desirous so to ornament; these should be commenced by means of a semi-circular-drill, or rotatory-cutter, formed with a collar to prevent its penetrating too far into the material; with this instrument a hemi-spherical recess is to be accurately bored at each end of each radial groove, and this operation may be thus performed:

Let the click-plate of the eccentric-chuck be fixed at that degree of eccentricity which corresponds to the position of the circles at the inner ends of the radial grooves, when the hemi-spherical recesses may be bored in the same manner as the eccentric circles are turned, with the exception of the cutting-tool being caused to revolve by means of a bow and sheave, instead of the work revolving. The recesses at the outer ends of the radial grooves are bored in a similar manner, after which the grooves may be cut by fixing a tool with a semi-circular cutting-edge on its side in the slide-rest, whilst the latter is traversed across the face of the work which is held perfectly still, and each pair of holes brought consecutively into the same horizontal line.

We will now proceed to detail those points which require attention in the execution of those complicated designs which require most of the foregoing apparatus for their production.

Fig. 98.

At fig. 98 we have shown a design for the top of a large snuff-box, the execution of which will require the employment of the rose-engine and the eccentric-chuck. The present case affords us an opportunity, not to be overlooked, of recapitulating the various methods of executing eccentric and segmental work, so that if the amateur is not desirous of producing those simple

forms to which we have previously alluded, he may not be put to the inconvenience of referring back for an account of these methods of working.

The top of the snuff-box being turned plain, and the edge on its circumference removed by turning a flute or groove upon it, we may commence our work at the centre, and we shall suppose that our design is strictly followed out. The small circle which is intended to be left plain in the centre of the box should be marked by a lead pencil while the work is yet on the common lathe, and also the circle which bounds the centre ornament, as well as those which indicate the positions of the centres of the semi-circular ends of the radial grooves, and that which bounds the outer ornamentation on the inner side; the positions of the centres of the small isolated circles are also marked.

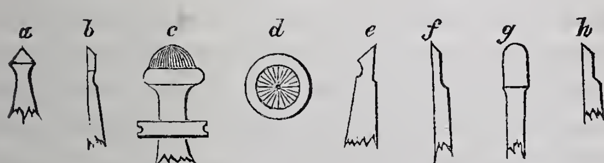
That circle of which the circumference passes through the centres of those eccentric of which the central figure is composed, must be now divided accurately into eight parts; each intersection will then determine the centre of an eccentric circle; the radius of this and the other circles of the same set is chosen so as to be equal to the radius of the divided circle.

Those circles which the circumferences pass through the centres of the ends of the radial grooves, and also those which pass through the centres of the small isolated circles, must be divided into sixteen equal parts, in order to obtain the exact positions of these centres, and the intersections must be so arranged

that those which refer to the radial grooves are on the same radial line, and also that the intersections which determine the position of the outer series of isolated circles may be on the same radial lines with the grooves; thus of these three circles it will only be necessary to divide one, the others being intersected by lines drawn from the centre of the work through the intersections on the circle so divided, and for this purpose the outer or largest circle should be selected for division, as the larger the circle the more accurately it can be divided, and also whatever errors may exist in the divisions of the outer circle, they may be reduced on the inner ones, whereas if the same amount of error occurred in the inner or smaller circle, it would be much magnified in the outer ones. The circle which refers to the centres of the inner series of isolated circles, must be so divided that radial lines drawn from its intersections fall exactly midway between the radial grooves.

Having thus set out the work, we next turn our attention to the form of the cutting-tools which will be required for the execution of the work.

FIG. 99.



In the accompanying figure we have represented all those apparatus which we are at all likely to require. At *a* is shown a top view of a fine point-tool, a side view being seen at *b*; a portion of this tool from the cutting-edge downwards through the distance of a few inches should be made thin, so that it may not be perfectly rigid, whereby it will be enabled to yield in case any hard speck should exist in the material, whereas a rigid tool would tear it out, thereby disfiguring the work: *e* and *f* are top and side views of another kind of point-tool, which may from its form be called a half-point-tool, being intended for the production of small circles, the centre parts of which are required to be cylindrical.

c and *d* are side and end views of a form of tool which may be used in various stages of the process; for instance, the figure to be produced may first be cut by the ordinary form of this cutter. The cutter is fixed in a swivel-handle, and worked by a bow-string after the manner of a drill, or it may be fixed immovably in the slide-rest while the work revolves upon the lathe-mandril; its cutting part consists of a semi-sphere, cut into grooves for the production of edges, and furnished with a collar to prevent its penetrating too far into the material. The figure having been thus cut, another semi-spherical tool is used, but, instead of being of steel, it is of some wood softer than the material to be operated upon, with or without grooves; it is supplied with some

abrasive material, such as very fine emery or glass-dust; and finally a somewhat larger one, supplied with some polishing powder, is employed to complete this part of the work.

At *g* and *h* we have shown the form of a tool intended to produce grooves of semi-circular section; they are, like the point-tools, made thin, in order to allow of their yielding, and thereby enabling them to produce smooth work when applied to the production of a design which is to be executed on heterogeneous material.

We will commence our work at the centre, removing the blank which has been properly marked out as above directed, together with the chuck in which it has been turned, and detached to the eccentric-chuck, which latter is previously attached to the lathe-mandril.

The click-plate which is attached to the eccentric-chuck is now to be so adjusted by means of the slider, that its eccentricity shall correspond to that of the circles of which the central ornamentation is composed.

One of the eccentric circles is now cut, after which the click-plate is caused to revolve through one-eighth of a revolution, or 45 deg., and another circle cut this process is repeated for each of the eight eccentric circles of which the centre ornament is composed·

The click-plate of the eccentric-chuck is now set to correspond to the eccentricity of the inner semi-

circular end of the radial grooves, and the rotatory-cutter *c, d,* attached to the slide-rest; one of the intersections determining the position of these semi-circles, is now brought opposite the end of the cutter, when the cutter may be caused to revolve by means of a bow, or if the cutter be fixed, the work may be caused to revolve by starting the lathe.

If it is intended to produce the radial grooves entirely by the action of the semi-spherical cutter, one of them must now be carved by one of the following methods: If the cutter rotates the work must gradually be moved by working the screw of the slider by hand; but if, on the contrary, the cutter be fixed, and the work is caused to revolve, to the head of the screw, by means of which the slide is adjusted, must be attached a star-shaped piece of metal, and a pin must be fixed to the lathe-poppet, in such a position that at each revolution of the work the screw of the slider shall be moved through a distance equal to that between the points of two rays of the star, and this process is continued until one groove is complete. The click-plate is now brought back to its former position, and caused to revolve through one-sixteenth of a revolution, or $22^1/_2$ deg., and another radial groove is cut, and the process repeated for each of the sixteen grooves.

These radial grooves may, if it be desired, be cut with the semi-circular tool; the tool being fixed in the slide-rest and advanced by the screw of the top-slide

a slight distance into the material, and the work traversed by means of the slider; but, before cutting the grooves, it will be necessary to bore, with the semi-spherical tool, recesses at each end of each groove, and the cut must be repeated until the groove is cut to the required depth.

We may now proceed to the execution of the various isolated circles, which may be produced by means either of the half-point tool or by the semi-spherical tool, according to the taste of the operator. For the production of each series of isolated holes, it will, of course, be necessary to adjust the eccentric chuck according to the eccentricity of the circles to be produced.

We may now complete the work by chasing the external design by means of the rose-engine, or one of its substitutes, and for this purpose a rosette with sixteen teeth must be used, this being the same whether the rose-engine, poppet-head, or movable rest be employed.

The work will now be completed, and may be polished by any convenient means.

We may also produce, by the assistance of these chucks, ornamental round and elliptical frames for photographs, &c.; we will take as an example of this kind of work the execution of an elliptical frame for a miniature.

A suitable material having been selected, it is cut externally to the required form, and a cut is also

made, indicative of the inner edge of the rim of the frame; a portion of the material contained in this inner ellipse is then removed, the substance being cut away to a sufficient depth to admit of the insertion of the miniature, sufficient material being left at the back to protect it from injury. Any sunken bosses which may be required may be produced by means of the eccentric-chuck alone, its eccentricity being altered previous to the execution of each boss. If any rose-engine ornamentation is required, it will be necessary to combine the elliptical-chuck with the rose-engine, or one of its substitutes.

By these means some very beautiful designs may be executed upon picture-frames, and after the amateur has had some practice in this art, he will be able to proceed to the execution of more delicate and complicated forms.

Before quitting the present interesting topic, we think it desirable once more to impress on the mind of the student the absolute necessity of maintaining the cutting edges of his tools in very perfect condition, a slight inaccuracy with regard to this point being exceedingly detrimental to works of the nature treated of in the present chapter, as the tools used for this purpose must be exceedingly delicate, and are frequently employed to act on various directions of the grain on the same work.

INDEX.

THE END.

PRINTED BY C. FEICHT. BERLIN, PRUSSIA.

Catalogue of Books

RELATING TO

PRACTICAL SCIENCE,

PUBLISHED AND SOLD BY

E. & F. N. SPON.

LONDON: 48, CHARING CROSS.

NEW YORK: 446, BROOME STREET.

Architects' Handbook.

A Handbook of Formulæ, Rules, and Memoranda, for Architectural Surveyors and others engaged in Building, by J. T. Hurst, C.E., ninth edition, royal 32mo, roan 5 0

André's Handbook of Mapping.

Containing Instructions for the Preparation of Engineering, Architectural, and Mechanical Drawings, *with numerous coloured examples*, crown 4to, cloth 15 0

Blast-Furnace.

Researches on the Action of the Blast-Furnace, by Charles Schinz, translated from the German by W. H. Maw, and Moritz Müller, *plates*, crown 8vo, cloth 8 6

Bridges.

Estimates and Diagrams of Railway Bridges for Turnpike, Public and Occupation Roads, in the Embankments of Double or Single Lines, and Cuttings of Double Lines, with Form for Calculating Quantities in Skew Structures, etc., also Culverts of various dimensions, and at Station Buildings, by J. W. Grover, M.I.C.E., second edition, enlarged, *with* 37 *coloured plates*, folio, cloth 31 6

Bridges.

Iron and Timber Railway Superstructures and General Works; giving Dimensions and Quantities for the Standard 4 ft. $8\frac{1}{2}$ in. gauge and the Metre 3 ft. $3\frac{3}{8}$ in. gauge, with some Earthwork Tables and Outlines of a Specification and Requirements, by J. W. Grover, M. Inst. C.E., folio, cloth £2 2 0

Bridges.

The Strains upon Bridge Girders and Roof Trusses, including the Warren, Lattice, Trellis, Bowstring, and other Forms of Girders, the Curved Roof, and Simple and Compound Trusses, by Thos. Cargill, C.E.B.A.T., C.D., Assoc. Inst. C.E., Member of the Society of Engineers, *with 64 illustrations, drawn and worked out to scale*, 8vo, cloth 12 6

Bridges.

Construction of the Great Victoria Bridge, in Canada, by James Hodges, Engineer to Messrs. Peto, Brassey, and Betts, Contractors, vol. 1, imp. 4to, *illustrated with 17 coloured plates, and numerous wood engravings;* vol. 2, royal folio, *containing* 28 *double and* 19 *single plates*, together 2 vols., half-bound in morocco £4 14 6

Bridges.

Long-Span Railway Bridges, comprising Investigations of the Comparative Theoretical and Practical Advantages of the various adopted or proposed Type Systems of Construction, with numerous Formulæ and Tables giving the weight of Iron or Steel required in Bridges from 300 feet to the limiting Spans; to which are added similar Investigations and Tables relating to Short-Span Railway Bridges, second and revised edition, by B. Baker, Assoc. Inst. C.E., *plates*, crown 8vo, cloth 5 0

Builders' Price-Book.

Spons' Builders' Pocket-Book of Prices and Memoranda, edited by W. Young, architect, royal 32mo, roan 4 6
or cloth, vermilion edges 3 6
Published annually.

Cabinet Making.

The Cabinet Maker; being a Collection of the most approved designs in the Mediæval, Louis-Seize, and Old English styles, for the use of Cabinet Makers, Carvers, etc., by R. Charles, 96 *plates*, folio, half-bound 21 0

Carpentry.

Elementary Principles of Carpentry, by Thomas Tredgold, revised from the original edition, and partly rewritten, by John Thomas Hurst, contained in 517 pages of letterpress, and *illustrated with* 48 *plates and* 150 *wood engravings*, crown 8vo, handsomely bound in cloth 18 0

Compensations.

A Text-book for Surveyors, in tabulated form, by Banister Fletcher, Associate of the Royal Institute of British Architects, crown 8vo, cloth 5 0

Coffee.

The Coffee Planter of Ceylon, by William Sabonadière, with an Appendix containing various extracts and letters from other authority, bearing on the same subject, second edition, enlarged and revised, *illustrated by plates and wood engravings*, crown 8vo, cloth 7 6

Coffee and Chicory.

Coffee and Chicory; the Culture, Chemical Composition, Preparation for Market, and Consumption, with simple tests for detecting adulteration, and practical hints for the Producer and Consumer, by P. L. Simmonds, F.S.S., author of 'The Commercial Products of the Vegetable Kingdom,' 'Dictionary of Products,' etc., etc., *illustrated by numerous wood engravings*, post 8vo, cloth 2 0

Cotton Cultivation.

Cotton Cultivation in its various details, the Barrage of Great Rivers, and Instructions for Irrigating, Embanking, Draining, and Tilling Land in Tropical and other Countries possessing high thermometric temperatures, especially adapted to the improvement of the cultural soils of India, by Joseph Gibbs, Member Institute Civil Engineers, *with* 5 *plates*, crown 8vo, cloth 7 6

Curves, Railway.

Treatise on the setting out of Railway Curves, with full Tables of the Angles, Distances, and Offsets required, especially arranged for the use of Measurements in feet and imperial links, but also adapted for the use of any other unit of Measurement, by David Livingstone, crown 8vo, cloth 10 6

Curve Tables.

Tables for setting out Railway Curves, arranged by Chas. Pullar Hogg, C.E., a series of cards arranged for Manipulation, with a sheet of Explanations and Examples, in neat cloth case 4 6

Dilapidations.

Dilapidations, a Text-book for Architects and Surveyors, in tabulated form, by Banister Fletcher, Asso. Rl. Inst. Brit. Arch. (Author of Model Houses), showing who are liable for Dilapidations, and the extent of the liability of Lessors, Lessees, Tenants at will, Tenants by elegit, Statute, Merchant, or Staple Tenants in fee simple, Tenants in tail, Tenants for life, Tenants for years without impeachment of Waste, Mortgagor, Mortgagee in Possession, Yearly Tenants, Tenants in common, and joint Tenants, Rights of coparceners, also what are dilapidations and waste, and further fully instructs the surveyor how to take and value them, to which is added the duties of surveyors, with a table of legal cases, embracing the most recent, and illustrated throughout by examples drawn from the author's experience, and latest legal decisions, 12mo, cloth 5 0

Earthwork Tables.

Tables for Computing the Contents of Earthwork in the Cuttings and Embankments of Railways, by W. Macgregor, royal 8vo, cloth 6 0

Economy in the Use of Steam.

A Statement of the Principles on which a Saving of Steam can best be effected. By Frank Salter, B.Sc., crown 8vo 3 6

Electrical Standards.

Reports of the Committee on Electrical Standards appointed by the British Association, revised by Sir W. Thomson, Dr. J. P. Joule, Professors Clerk Maxwell, and Fleeming Jenkin, with a Report to the Royal Society on Units of Electrical Resistance, by Prof. F. Jenkin, edited by Professor Flemin Jenkin, F.R.S., *plates*, 8vo, cloth 9 0

Electric Telegraph.

Electrical Tables and Formulæ for the Use of Telegraph Inspectors and Operators, compiled by Latimer Clark and Robert Sabine, *with wood engravings*, crown 8vo, cloth — 12 6

Engineering.

Spons' Dictionary of Engineering, Civil, Mechanical, Military, and Naval, with technical terms in French, German, Italian, and Spanish, 3100 pp., and *nearly* 8000 *engravings*, super-royal 8vo, in

8 divisions, cloth, 13*s.* 6*d.* each	£5 8 0
8 „ half-morocco	£6 8 0
8 „ French morocco	£7 4 0
Complete in 3 vols., cloth	£5 5 0
Bound in a superior manner, half-morocco, top edge gilt, 3 vols.	£6 12 0

Engineers' Companion.

The Office and Cabin Companion for Engineers and Officers of Steam Vessels, consisting of observations, rules, and tables to facilitate such Calculations as Naval Officers and Engineers are called upon to make, by J. Simond Holland, second edition, 12mo, cloth — 3 0

Engineering Drawing.

An Elementary Treatise on Orthographic Projection, being a new method of Teaching the Science of Mechanical and Engineering Drawing, intended for the instruction of Engineers, Architects, Builders, Smiths, Masons, and Bricklayers, and for the use of Schools, *with numerous illustrations on wood and steel*, by William Binns, Associate Institute Civil Engineers, late Master of the Mechanical Drawing Class at the Department of Science and Art, and at the School of Mines, formerly Professor of Applied Mechanics, at the College for Civil Engineers, &c., seventh edition, 8vo, cloth — 9 0

Mr. Binns' system of Mechanical Drawing is in successful operation in all the Art Schools of the United Kingdom.

Engineering Drawing.

The Second Course of Orthographic Projection; being a continuation of the New Method of Teaching the Science of Mechanical and Engineering Drawing; with some Practical Remarks on the Teeth of Wheels,

the Projection of Shadows, Principles of Shading, and the Practice of Making to Scale Drawings from Actual Machinery. Intended for the Instruction of Engineers, Architects, Builders, Smiths, Masons, and Bricklayers, and for the use of Science Schools and Classes, *with numerous illustrations*, by William Binns, Consulting Engineer, Associate I.C.E., late Master of the Mechanical Drawing Class at the Department of Science and Art, and at the Royal School of Mines; formerly Professor of Applied Mechanics at the College for Civil Engineers, etc., 8vo, cloth — 10 6

Engineers' Pocket-Book.

The Pocket-Book of Pocket-Books, being Molesworth and Hurst's Pocket-Books, printed on thin paper and bound together in one volume, royal 32mo, russia, gilt edges — 12 6

Engineers' Pocket-Book.

A Pocket-Book of Useful Formulæ and Memoranda for Civil and Mechanical Engineers, by Guilford L. Molesworth, Member of the Institute of Civil Engineers, Consulting Engineer to the Government of India for State Railways, seventeenth edition, revised, with considerable additions by the author, containing one hundred and fifty additional pages, royal 32mo, roan — 6 0

Ditto, Interleaved with ruled Paper for Office use — 9 0

Engineers' Price-Book.

Applebys' Illustrated Handbook of Machinery and Iron Work, with the Cost, the Working Expenses, and the Results obtained in the use of Steam and Hand Cranes, Pumps, Fixed and Portable Steam Engines, and various other Machines; with Weight, Measurement, etc., etc.; also Prices of Tools, Iron Works, Stores, and Materials required by Civil and Mechanical Engineers, Merchants, and others; together with numerous Tables and Memoranda, by Appleby Bros., Engineers, *many hundred wood engravings*, 8vo, cloth — 12 6

Engineers' Tables.

Spons' Tables and Memoranda for Engineers, selected and arranged by J. T. Hurst, C.E., Author of 'Architectural Surveyors' Handbook,' 'Hurst's Tredgold's Carpentry,' etc., 64mo, roan, gilt edges — 1 0

French Measures.

French Measures and English Equivalents, by John Brook. For the use of Engineers, Manufacturers of Iron, Draughtsmen, etc., 18mo, roan — 1 0

"In a series of compact tables the English values of the French measures are arranged from one to a thousand millimetres, and from one to a hundred metres; the fractions of an inch progressing in sixteenths are also reduced to French values. The little book will be found useful to almost every engineer."—*Engineering.*

French-Polishing.

The French-Polisher's Manual, by a French-Polisher, containing Timber Staining, Washing, Matching, Improving, Painting, Imitations, Directions for Staining, Sizing, Embodying, Smoothing, Spirit Varnishing French-Polishing, Directions for Re-polishing, royal 32mo, sewed — 0 6

Gas.

Analysis, Technical Valuation, Purification and Use of Coal Gas, by the Rev. W. R. Bowditch, M.A., *with wood engravings*, 8vo, cloth — 12 6

Gas Works.

Instructions for the Management of Gas Works, by W. C. Holmes, Engineer and Contractor for Gas Works, Whitestone Ironworks, Huddersfield, demy 8vo, cloth — 4 0

Gunner's Pocket-Book.

Bridges' Gunner's Pocket-Book, compiled by Captain T. W. Bridges, H.P. Royal Artillery, crown 32mo, roan, 1s.; or morocco — 1 6

Heat.

A Practical Treatise on Heat, giving Data, Rules, and Tables to facilitate the practical application of the Laws of Heat to the Useful Arts; illustrated by examples worked out in detail for the use of Engineers, Architects, etc., by Thomas Box, Author of 'Practical Hydraulics,' *numerous plates*, post 8vo, cloth — 8 6

Hydraulics.

Practical Hydraulics: a Series of Rules and Tables for the use of Engineers, etc., etc., by Thomas Box, third edition, *numerous plates*, post 8vo, cloth — 5 0

Iron.

Iron as a material of Construction, forming a Handbook for the use of Students in Engineering, by William Pole, C.E., F.R.S., *cuts*, post 8vo, cloth — 6 0

Iron Construction.

Works in Iron, Bridge and Roof Structures, by Ewing Matheson, *numerous engravings*, royal 8vo, cloth 15 0

Iron and Steel.

The Journal of the Iron and Steel Institute, edited by Jno. Jones, F.G.S., and David Forbes, F.R.S., published half-yearly, 8vo, each Part 7 6

Indian Engineering.

India and Indian Engineering, three Lectures delivered at the Royal Engineer Institute, Chatham, in July, 1872, by Julius George Medley, Lieut.-Col. R.E., Assoc. Inst. C.E., Fellow of the Calcutta University, Principal Thomason Civil Engineering College, Roorkee, crown 8vo, cloth 3 0

Link-Motion.

Link-Motion and Expansion-Gear practically considered, by N. P. Burgh, Engineer, *illustrated with 90 plates and 229 wood engravings*, small 4to, handsomely half-bound in morocco £2 2 0

Mechanical Engineering.

The Mechanician and Constructor for Engineers, comprising Forging, Planing, Lining, Slotting, Shaping, Turning, Screw Cutting, etc., by Cameron Knight, *illustrated by* 96 4to *plates, containing* 1147 *illustrations, and* 397 *pages of letterpress*, 4to, half morocco £2 12 6

Mechanics.

The Essential Elements of Practical Mechanics, based on the principle of work, designed for Engineering Students, by Oliver Byrne, formerly Professor of Mathematics, College for Civil Engineers, second edition, *illustrated by numerous wood engravings*, post 8vo, cloth 7 6

Mechanics.

Principles of Mechanics and their application to Prime Movers, Naval Architecture, Iron Bridges, Water-Supply, &c., by W. J. Millar, C.E., Secretary of the Institute of Engineers and Ship-builders in Scotland, crown 8vo, cloth 4 6

Metric Weights and Measures.

Scales for the Ready Comparison of British and Metric Weights and Measures, by A. L. Newdigate, M.A., in neat cloth case 5 0

Military Terms.

A Handy Dictionary of Military Terms, by Major W. W. Knollys, F.R.G.S., 93rd Sutherland Highlanders, Garrison Instructor, Home District, etc., 18mo, cloth 2 0

Mill Gearing.

A Practical Treatise on Mill Gearing, Wheels, Shafts, Riggers, etc., for the use of Engineers, by Thomas Box, post 8vo, cloth, *with 8 plates* 5 0

Millwright's Guide.

The Practical Millwright's and Engineer's Ready Reckoner, or Tables for finding the diameter and power of cog-wheels, diameter, weight, and power of shafts, diameter and strength of bolts, etc., by Thomas Dixon, third edition, 12mo, cloth 3 0

Mine Engineering.

A New Edition of a Practical Treatise on Mine Engineering, by G. C. Greenwell, F.G.S , Colliery Viewer, Member of the North of England Institute of Mining Engineers, &c., &c., &c., *containing 64 coloured plates drawn to a large seale, and 255 pp. of letterpress*, imp. 4to, handsomely half-bound in morocco £2 15 0

Mining.

Records of Mining and Metallurgy; or, Facts and Memoranda for the use of the Mine Agent and Smelter, by J. Arthur Phillips and John Darlington, in crown 8vo, cloth, *illustrated with wood engravings* 4 0

Narrow Gauge Railways.

Narrow Gauge Railways, by C. E. Spooner, C.E., F.G.S., *illustrated with 25 folding plates*, 8vo, cloth 12 6

CONTENTS :—

Copy of paper read at the "Inventors' Institute" on Narrow Gauge Railways — the Festiniog Railway — Experiment on the Festiniog Railway — Captain Tyler's Report — The Railways of the Future — Advantages gained by Narrow Gauge Railways — Railway Gauges — Narrow Gauge Rolling Stock — Battle of the Gauges — Indian Railway Gauges and Rolling Stock, etc.

Outpost Duty.

Practical Lessons in Reconnoitring, Outpost Duty, etc., suggested by the late Autumn Manœuvres, Nos. 1 and 2 each 1 6

Perpetual Motion.

Perpetuum Mobile; or, Search for Self-Motive Power during the 17th, 18th, and 19th Centuries, illustrated from various authentic sources in papers, essays, letters, paragraphs, and numerous patent specifications, with an Introductory Essay by Henry Dircks, C.E., *with numerous engravings of machines*, crown 8vo, cloth 10 6

" " Second Series, *with numerous engravings and portraits*, crown 8vo, cloth 10 6

Railway Crossings.

Switches and Crossings; Formulæ for ascertaining the Angles of Crossings, the Lengths of Switches, and the Distances of the Points of the Crossings and the Heels of the Switches from the Springing of the Curve, by W. Donaldson, M.A., A.I.C.E., Author of 'A Treatise on Oblique Arches,' *plates*, 8vo, cloth 10 6

Reservoirs

On the Construction of Catch-water Reservoirs in Mountain Districts for the supply of Towns, or for other purposes, by C. H. Beloe, Author of 'The Handbook of the Liverpool Water-works,' *plates*, 8vo, cloth 5 0

Railway Engineering.

Manual of Railway Engineering, for the Field and the Office, by Charles P. Cotton, C.E., second edition, revised and enlarged, post 8vo, cloth 7 6

Retaining Walls.

Surcharged and different Forms of Retaining Walls, by J. S. Tate, *cuts*, 8vo, sewed 2 0

Ropemaking.

A Treatise on Ropemaking as practised in public and private Rope-yards, with a description of the manufacture, rules, tables of weights, etc., adapted to the Trade, Shipping, Mining, Railways, Builders, etc., by R. Chapman, formerly foreman to Messrs. Huddart and Co., Limehouse, and late Master Ropemaker to H.M. Dockyard, Deptford, second edition, 12mo, cloth 3 0

Sanitary Engineering.

Sanitary Engineering, a Guide to the Construction of Works of Sewerage and House Drainage, with Tables for facilitating the Calculations of the Engineer, by Baldwin Latham, C.E., Mem. Inst. C.E., Past President of the Society of Engineers, etc., 21 *plates and* 112 *woodcuts*, 8vo, cloth 30 0

Sewage.

A Handbook of Sewage Utilization, by Ulick Ralph Burke, Esq., Barrister-at-Law, crown 8vo, cloth 3 6

This work treats: I. Of the evils of the present system of Sewage Treatment, the Pollution of Water, and the Waste of Manure. II. Remedies, Privy, and Ash-pit; Eureka System; Milan, Goul, and Moule's Systems. III. Treatment of Sewage by Chemical means; Experiments with Lime; Lime and Chloride of Iron; Sulphate of Ammonia; Holden's Process; Sulphate of Alumina; Persalts of Iron; Blyth, Lenk, Phosphate, A.B.C., Scott, and Hille Processes; Filtration. IV. Irrigation. With an APPENDIX, including the Law relating to Sewage Utilization.

Sewage.

The Sewage Question. Part 1. The Water Carriage System, with an account of the Lime and Cement Process of Major-Gen. H. Y. D. Scott, C.B. Part 2. Interception Systems, with suggestions by Major-Gen. Scott for the Extraction of Concentrated Manures from Sewage, 2 parts, 8vo, sewed 2 0

Silver Mines.

Vazeeri Rupi, the Silver Country of the Vazeers, in Kulu: its Beauties, Antiquities, and Silver Mines, including a Trip over the lower Himalayah Range and Glaciers, by J. Calvert, F.G.S., Mem. Inst. C.E., *illustrated with a map and coloured plates*, 8vo, cloth 16 0

Slide-Valve.

The Slide-Valve practically considered, by N. P. Burgh, Engineer, fourth edition, *containing* 88 *illustrations, and* 121 *pages of letterpress*, crown 8vo, cloth 5 0

Specifications.

Practical Specifications of Works executed in Architecture, Civil and Mechanical Engineering, and in Road Making and Sewering; to which are added a Series of Practically useful Agreements and Reports, by John Blenkarn, *with* 15 *folding plates*, 8vo, cloth 18 0

List of Plates.

1.—Elevations and Plans of Cottages at Barnet.
2.—Elevations and Plans of Houses at Maidstone.
3.—Elevation and Section of Villa at East Cowes.
4.—Ground and First Floor of Do.
5.—Elevation of Villa at East Cowes.
6.—Ground and First Plan of Do.
7.—Details of Sewer Work.
8.—Details of Ironwork, Piling.
9.—Details of Ironwork.
10.—Details of Ironwork, Piling, &c.
11.—Section of Artesian Well.
12.—Elevation and Section of Wrought-Iron Bridge.
13.—Plan, Elevation, and Section of Wrought-Iron and Brick Bridge.
14.—Section and Plan of Engine and Engine House.
15.—Elevation of Timber Bridge.

Steam Boilers.

New Work on Boiler Engineering, complete in 20 parts, 19 at 3*s*., and 1 at 6*s*., or handsomely half-bound morocco, cloth sides, £3. 13*s*. 6*d*., a Practical Treatise on Boilers and Boiler Making, by N. P. Burgh, Mem. Inst. Mech. Eng., *illustrated with numerous wood engravings and plates of working drawings* £3 13 6

Steam Engine.

Modern Marine Engineering applied to Paddle and Screw Propulsion; consisting of 36 *plates*, 259 *wood engravings*, and 403 pages of descriptive matter, the whole being an exposition of the present practice of the following firms:—Messrs. J. Penn and Sons; Maudslay, Sons, and Field; James Watt and Co.; J. and G. Rennie; R. Napier and Sons; J. and W. Dudgeon; Ravenhill and Hodgson: Humphreys and Tennant; Mr J. F. Spencer; and Messrs. Forester and Co. By N. P. Burgh, Engineer, 4to, cloth £2 5 0

Steam Engine.

Modern Compound Engines, being a Supplement to Modern Marine Engineering, by N. P. Burgh, Mem. Inst. Mech. Eng., *numerous large plates of working drawings*, 4to, cloth 18 0

The following Firms are contributing Working Drawings of their best and most modern examples of Engines fitted in the Royal and Mercantile Navies:—Messrs. Maudslay, Rennie, Watt, Dudgeon, Humphreys, Ravenhill, Jackson, Perkins, Napier, Elder, Laird, Day, Allibon.

Steam Engine.

Practical Treatise on the Condensation of Steam; contained in 262 pages of letterpress, *and illustrated with* 212 *engravings*, by N. P. Burgh, Engineer, super-royal 8vo, cloth £1 5 0

Steam Engine.

Practical Illustrations of Land and Marine Engines, showing in detail the modern improvements of High and Low Pressure, Surface Condensation and Superheating, together with Land and Marine Boilers, by N. P. Burgh, Engineer, 20 *plates in double elephant*, folio, cloth £2 2 0

Steam Engine.

A Pocket-Book of Practical Rules for the Proportions of Modern Engines and Boilers for Land and Marine purposes, by N. P. Burgh, 4th edition, revised, with Appendix, royal 32mo, roan 4 6

Details of High-Pressure Engine, Beam Engine, Condensing, Marine Screw Engines, Oscillating Engines, Valves, etc., Land and Marine Boilers, Proportions of Engines produced by the rules, Proportions of Boilers, etc.

Steep Gradients on Railways.

A Treatise on the Improved Method for overcoming Steep Gradients on Railways, whereby an ordinary locomotive capable of hauling a given load up a gradient 1 in 80, can take the same up 1 in 8, by Henry Handyside, 8vo, sewed 1 0

Strength of Beams.

On the Strength of Beams, Columns, and Arches, considered with a view to deriving methods of ascertaining the practical strength of any given section of Beam, Column, or Arch, in Cast Iron, Wrought Iron, or Steel, by B. Baker, *numerous cuts*, crown 8vo, cloth 9 0

Strength of Beams.

New Formulas for the Loads and Deflections of Solid Beams and Girders, by William Donaldson, M.A., Assoc. Inst. C.E., 8vo, cloth 4 6

Sugar.

The Practical Sugar Planter; a complete account of the cultivation and manufacture of the sugar-cane, according to the latest and most improved processes, describing and comparing the different systems pursued in the East and West Indies, and the Straits of Malacca, and the relative expenses and advantages attendant upon each, being the result of sixteen years' experience of a sugar-planter in those countries, by Leonard Wray, Esq., *with numerous illustrations*, 8vo, cloth 10 6

Short Logarithms.

Short Logarithmic and other Tables, intended to facilitate Practical Calculations, and for solving Arithmetical Problems in class, 8vo, sewed — 1 0

Ditto, cloth — 1 6

Sulphuric Acid.

The Chemistry of Sulphuric Acid Manufacture, by Henry Arthur Smith, *cuts*, crown 8vo, cloth — 4 6

Surveying.

The Principles and Practice of Engineering, Trigonometrical, Subterraneous, and Marine Surveying, by Charles Bourne, C.E., third edition, *numerous plates and woodcuts*, 8vo, cloth — 5 0

Surveying.

A Practical Treatise on the Science of Land and Engineering Surveying, Levelling, Estimating Quantities, etc., with a general description of the several Instruments required for Surveying, Levelling, Plotting, etc., by H. S. Merrett, 41 *fine plates, with illustrations and tables*, royal 8vo, cloth — 12 6

Table of Logarithms.

Table of Logarithms of the Natural Numbers, from 1 to 108,000, by Charles Babbage, Esq., M.A., Stereotyped edition, royal 8vo, cloth — 7 6

Tables of Squares and Cubes.

Barlow's Tables of Squares, Cubes, Square Roots, Cube Roots, Reciprocals of all Integer Numbers up to 10,000, post 8vo, cloth — 6 0

Teeth of Wheels.

Camus (M.) Treatise on the Teeth of Wheels, demonstrating the best forms which can be given to them for the purposes of Machinery, such as Mill-work and Clock-work, and the art of finding their numbers, translated from the French, third edition, carefully revised and enlarged, with details of the present practice of Millwrights, Engine Makers, and other Machinists, by Isaac Hawkins, *illustrated by* 18 *plates*, 8vo, cloth — 5 0

Telegraphy.

Journal of the Society of Telegraph Engineers, including original Communications on Telegraphy and Electrical Science, edited by Major Frank Bolton and G. E. Preece. Parts I. to VII., demy 8vo, sewed, *with wood engravings*, each 5 0
To be continued quarterly.

Torpedo Warfare.

A Treatise on Coast Defence; based on the experience gained by Officers of the Corps of Engineers of the Army of the Confederate States, and compiled from Official Reports of Officers of the Navy of the United States, made during the North American War from 1861 to 1865, by Von Scheliha, Lieutenant-Colonel and Chief Engineer of the Department of the Gulf of Mexico, of the Army of the late Confederate States of America; *with numerous fine plates*, imperial 8vo, elegantly bound in cloth, top edge gilt 15 0
Or with the plates coloured 30 0

Trevithick.

The Life of Richard Trevithick (Inventor of the High-pressure Steam-engine), with an account of his Inventions, by Francis Trevithick, C.E., 2 vols, medium 8vo, cloth, *illustrated by a steel portrait, lithographs, and numerous beautiful wood engravings, including many accurate illustrations of Cornwall, its Mines, and Mining Machinery*, reduced to 12 6

Turbine.

A Practical Treatise on the Construction of Horizontal and Vertical Water-Wheels, *with* 11 *plates*, specially designed for the use of operative mechanics, by William Cullen, Millwright and Engineer, second edition, revised and enlarged, small 4to, cloth 12 6

Turning.

The Practice of Hand-turning in Wood, Ivory, Shell, etc., with Instructions for Turning such work in Metal as may be required in the Practice of Turning in Wood, Ivory, etc., also an Appendix on Ornamental Turning, by Francis Campin, second edition, *with wood engravings*, crown 8vo, cloth (a book for beginners) 6 0

Valve-Gears.

Treatise on Valve-Gears, with special consideration of the Link-Motions of Locomotive Engines, by Dr. Gustav Zeuner, third edition, revised and enlarged, translated from the German, with the special permission of the author, by Moritz Muller, *plates*, 8vo, cloth 12 6

Ventilation.

Health and Comfort in House Building, or Ventilation with Warm Air by Self-Acting Suction Power, with Review of the mode of Calculating the Draught in Hot-Air Flues, and with some actual Experiments, by J. Drysdale, M.D., and J. W. Hayward, M.D., demy 8vo, *with plates*, cloth 7 6

Weight of Iron.

Tabulated Weights of Angle, T, Bulb, and Flat Iron, for the use of Naval Architects and Ship-builders, by Charles H. Jordan, M.I.N.A., 18mo, sewed 1 6

Wood-working Factories.

On the Arrangement, Care, and Operation of Wood-working Factories and Machinery, forming a complete Operator's Handbook, by J. Richards, Mechanical Engineer, *woodcuts*, crown 8vo, cloth 5 0

Wood-working Machines.

A Treatise on the Construction and Operation of Wood-working Machines, including a History of the Origin and Progress and Manufacture of Wood-working Machinery, by J. Richards, Mechanical Engineer, 25 *folding plates, and nearly* 100 *full-page illustrations* of English, French, and American Wood-working Machines in modern use, selected from the designs of prominent Engineers, 4to, cloth £1 5 0

Workshop Receipts.

Workshop Receipts for the use of Manufacturers, Mechanics, and Scientific Amateurs, by Ernest Spon, crown 8vo, cloth 5 0

Yachts.

Yachts and Yacht-Building, being a Treatise on the construction of Yachts and other matters relating to Yachting, by P. R. Marett, second edition, enlarged, *illustrated with* 12 *folding plates*, demy 8vo, cloth 12 6

4/83
ILXX
5256

GETTY CENTER LIBRARY
3 3125 00140 7747

ND
Y
HTON
AND
OGE